CONTRIBUTIONS TO THE MORPHOLOGY OF LEPIDOPTERA.

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WHEN studying the literature relating to the classification and phylogeny of Lepidoptera, I have always been struck with the paucity of characters which are taken as the basis of classificatory work in this order of insects. Outline of antennae and their joints, venation of wings, form of legs, presence or absence of rostrum and frenulum, are generally the only characters of the imago state taken into consideration in the distinction of groups higher than species, the trunk of the body being almost entirely neglected. The reason why it is so is not far to seek. Notwithstanding that a considerable number of papers have been written on the morphology of single species or genera of Lepidoptera, we have no work dealing with the morphology of the whole order in an intrinsic manner. North American entomologists, the fortunate—from an entomological point of view—possessors of crop-destroying insects, have done a great deal in this branch of our science : the only books, indeed, where one can expect to find, and finds, valuable remarks on the morphology of various families of Lepidoptera are Scudder's *Butterflies of New England*, often copied verbally by prolific old-world writers on Butterflies, and various works of Packard, Compstock, and others.

Every new fact in the morphology of any group of animals is of some interest ; a contribution to the morphology of Lepidoptera must, I think, be of special value even if the new facts are few. During my researches in this order of insects I have often come across peculiarities in the morphology which, by themselves, seemed to me to be of great significance and worth publishing. But instead of giving stray notes on the morphology of Lepidoptera, I have thought it better to work up the various organs and confine my notes at one time to a single portion of the body. I have, therefore, divided my contributions into several instalments, of which I present herewith the first to the reader. I shall thus avoid the paper becoming so bulky that nobody will care to wade through it. Further, the separate treatment of the different organs will have the great advantage (1) to the reader, that he can keep the facts more easily in view and hence be able to follow my inductions critically, and (2) to me, that—my researches being undertaken to gain a better insight into the phyletic connection between the higher divisions of Lepidoptera down to families—I can draw up a grouping of the families from each organ independently of the distinguishing characters furnished by other parts of the body, and then finally, after the treatment of all parts of at least the exoskeleton, come to a satisfactory result as to phylogeny and classification by a comparison of the conclusions arrived at in each instalment of these contributions. However, it must be understood that, as the number of Lepidopterous insects is so very large, these contributions are not meant to be anything approaching a complete treatment of the exoskeleton of the order : all I have done is to gather from an almost unworked gold-field those nuggets on which I stumbled—and of which some may be proved by future research to be below weight, containing more rock than gold.

I. THE ANTENNAE OF BUTTERFLIES.

(Plates XIV., XV.)

Although the antennae of Butterflies are made use of in diagnosing the families, subfamilies, and even genera in the handbooks and special articles treating upon these insects, it is generally only the length of the organ, its shape, and especially the outline of the distal thickened portion, the club, which are taken into account; while the special structure of the joints, the sense-organs they bear, and the covering of scaling have never been comparatively studied to any extent. It is true that the histology of the sense-hairs has often been the subject of research, that the occurrence of special structures of the skeleton of the joints is mentioned by many writers, that even attempts have been made to find out how far that which is found to be true in one species holds good in other species of the same family, and whether there are distinguishing characters between the families in these organs; but as yet the attempts have been failures. Messrs. Godman & Salvin * have noticed the grooves of the antenna in *Pieridae*, but erroneously attribute four instead of three grooves to a joint in *Dismorphiinae*; Moore † gives as a special feature of the antennae of the Nymphalid genus *Charaxes* that the club has a slight treble carina on its inner edge, a character not confined to *Charaxes*, but found in all *Nymphalidae*; and similar observations are scattered over the mass of writings on Butterflies. More detailed and extensive remarks we find, of course, in the works on North American Lepidoptera. Thus we read in Scudder ‡ that "often one or two slender carinae are to be seen upon the under surface and some little dimple-like depressions arranged in a longitudinal row," and notice also valuable remarks on special features of the antennae in the descriptions of the various families, genera, and species. But by far the most extensive researches ever made on these organs are laid down in a paper by Dr. Bodine in 1896.§ Here for the first time the antennae of a great number of families (nearly all) of Lepidoptera are studied in detail, and the often remarkable differences in the structure of the joints observed by Dr. Bodine applied to classification. This work has brought our knowledge of the antennae a long step forwards, and must be recommended heartily for perusal to Lepidopterists in spite of a few erroneous generalisations. In respect to Butterflies, Bodine's classificatory results are rather meagre (and in part incorrect, as we shall see later on). He gives the absence of "cones" from the Butterfly antenna as a character by which the Butterflies are distinguished from other *Frenatae*, differentiates the *Hesperiidae* by the ventral expansion of the distal joints, characterises the antennae of *Papilionidae* by the presence of "short hairs or rods," which are (erroneously) said to be absent from other families of Butterflies, the absence of "pits of the usual kind," and the absence of scales (which, however, are present in very many Papilios), and then proceeds to say (*l.c.* p. 46) that he was "unable to find any definite characters in the antennae themselves which are constant for the separate families, and which will separate the Pieridae, Lycaenidae and Nymphalidae. The Pieridae, however, differ from the Lycaenidae in the insertion of their antennae. . . . The Nymphalidae have the most highly organised antennae of all the butterflies. They are abundantly

* *Biol. Centr. Amer., Rhop.* II. p. 173 (1879).

† *Butterflies of India* II. p. 249 (1896).

‡ *Butterflies of the Eastern United States and Canada, with special Reference to New England*, 1889, p. 38.

§ Bodine, "The Taxonomic Value of the Antennae of the Lepidoptera," in *Trans. Amer. Ent. Soc.* XXIII. pp. 1—56. t. I.—V. (1896).

supplied with well-developed pits. The clavola has pits upon the ventral surface, even to the proximal segment in some forms, and there are other indications that these forms express the highest antennal development among the butterflies." And on p. 48 Dr. Bodine, speaking of the antennae of the whole order, concludes: "In the determination of the relationships of the larger groups they do not furnish as good guides as some of the larger organs, for while they are subject to great variation, they do not afford a sufficiently large basis for variation to leave a stable and constant ground-work for the tracing out of the paths by which the specializations are brought about. . . . Owing to the difficulty of observation and the necessity for especial preparation, they afford few characters which would be practicable for recognition characters in ordinary systematic work, but for the more careful and painstaking work of the study of the relationships they are of great value." I quite agree with Dr. Bodine that a comparative study of the histology of the antennae, which he has specially in view, will furnish us with facts which will throw light upon the relationship of the various groups of Butterflies and be of great value to the classifier as well as the general biologist. But I fear the time is very distant when a number of forms large enough to admit generalisations will have been studied histologically.

I have, therefore, abstained from giving histological details, confining my notes to the special structure of the joints, and the development of the sense-hairs and scaling, which give, in contradiction of what Bodine says (see above), excellent "recognition characters for ordinary systematic work," and enable us also to recognise the lines of development which led to the various specialised antennae. A closer comparison of the antennae of such Butterflies the position of which has been left doubtful by many authors reveals at once to which family or group the species belong. Thus there can be no doubt that *Styx infernalis*, standing among the *Pieridae*, has Erycinid antennae, while *Pseudopontia paradoxa*, considered by Butler and others to be a moth, has certainly Pierid antennae; *Papilio zalmoxis*, treated by Standinger, Schatz, Rippon, and others as an "Ornithoptera" on account of its size, has the antennae not of the "Ornithoptera" type, but similar to those of *Papilio merope*, *zenobia*, and allies; *Mesapia*, described as a Papilionid, has Pierid antennae; *Alaena amazoula*, considered to be a small Acraeid until Schatz removed the genus to the *Lycaenidae* on account of the development of the anterior legs, has the antennae very different from *Acraeidae*, they being typically Lycaenid; and so on. It is quite impossible to mistake a Nymphalid antenna for that of a Lycaenid or Pierid; *Libythea*, for instance, has Nymphalid antennae, and is in this respect widely different from the *Erycinidae* to which it is linked by de Nicéville and others; and the antennae of these families are equally well distinguished from those of *Papilionidae*.

I have endeavoured to find and have selected more easily traceable morphological characters, which mostly can be recognised with the help of an ordinary pocket-lens; in fact, I have tried to bring together especially such details as may be studied at dry individuals without removing the antennae from the specimens. By restricting thus the field of observation in respect to each single antenna, and hence necessarily curtailing the number of distinguishing characters to be found, I had a twofold aim: firstly, I hoped to interest in these structural characters the average Lepidopterist who naturally abhors all methods of research by which his specimens get damaged, and to induce the monographer to pay due attention to these organs, which will often give him valuable hints, where other

organs fail; and secondly, I was, in consequence of the adoption of this method of research, enabled to compare many thousands of specimens, inclusive of great rarities and aberrant forms which no museum can allow to fall a victim to the microtome.

The organs of the antenna which are the principal subject of this paper are the following four :—

(1) Scales, covering generally the dorsal surface of the antenna, but very often also developed ventrally, and in many cases absent.

(2) Fine sense-hairs,* covering the not-scaled ventral surface of the joints or part of it, much varying in length, sometimes different in the two sexes of a species; sometimes very short and rather broad; mostly of a silvery hue.

(3) Setiferous punctures, found especially at the sides of the joints in those families where the fine sense-hairs are restricted in extent (*Nymphalidae*, *Papilionidae*); the puncture is generally rather conspicuous, the seta very short. There is no distinct line of separation between (3) and (2).

(4) Sense-bristles, standing on the scaled and not-scaled portion of the joints, varying much in length, often regularly arranged.

To these four special organs comes as a fifth feature of the antenna the often peculiarly specialised configuration of the surface of the joints.

A. Description of the Antennae of Butterflies.

To give the description of all the antennae examined would mean a very lengthy paper, which would be of little value, firstly, because it would not give the description of the antennae of all the species known, since I have certainly **not** examined them all, and secondly, because it would require an extensive summary, if the reader should be enabled to see in each family the state of development of the various organs mentioned above. I give, therefore, a description of the features of the antennae of a family or subfamily as a whole, and mention genera and species merely as examples at which this or that state of development may be observed. Hence the mentioning of a generic or specific name does not mean that a certain feature occurs in that genus or species only, unless this be expressly stated.

1. *HESPERIIDAE.*

As in many other Butterflies and some Moths, the joints of the club of the antennae of the *Hesperiidae* are longer and wider ventrally than dorsally; if the difference between the dorsal and ventral expansion is great, the club assumes necessarily the form of a hook, a character which we meet with in most *Hesperiidae* and to such a degree in no other Lepidoptera, and hence may be called a typically Hesperid character. On the other hand, there is a good number of Hesperids in which the ventral expansion of the club is not greater or even less (*Aegiale kollari*) than in many other Butterflies.

The joints are either cylindrical or conical, those of the club sometimes slightly flattened, or their ventral surface is mesially somewhat raised (f. 4, *Entheus gentius*, 1779); there are never costa-like raised lines, or grooves.

The scaling is very much extended; in nearly all species it covers the whole

* For literature upon the histology of the various kinds of sense-organs of the antennae see Bodine, *l.c.*

dorsal surface inclusive of the last joint, only in a few forms the last joint is bare of scales: a greater restriction of the dorsal scaling as is so often the case in all other families of Butterflies never takes place. Also the ventral side of the stalk and of the most proximal joints of the club is scaled all over in all the species, and in many Hesperids the scaling occupies the greater number of the joints of the club. However, there remains always a not-scaled area, occupying in every case the ventral side of the distal joints. In the species with a long recurved club the dorsal scaling is arranged in two regular transverse rows on each joint of the club, while in the other *Hesperiidae*, especially constantly in those with a short club, the scaling is of irregular arrangement. On the stalk the scales never stand in regular rows. The not-scaled ventral area, though pretty constant in extent in the same group of species, is very variable as regards the whole family. In many species it occupies only the eight or nine distal joints (*Heteropterus palaemon*); in others it extends farther down the club, occupying, for instance, in the large genus *Pyrrhopyga* from eighteen to twenty-five joints, in *Ismene* up to thirty-seven, and reaches its maximum size in *Euschemon rafflesiae*, in which species it extends over forty joints. But, however different in extent the not-scaled space may be in the various skippers, there are two remarkable characters common to all species: (1) the bare area never extends down to the stalk, which is invariably scaled all over; and (2) the area is one whole, never being interrupted by scaling, as is so often the case in other families.

The fine sense-hairs vary much in length in the different species. They are evenly distributed over the not-scaled (ventral) area (figs. 1 to 4); but in a few species (f. 2, *H. palaemon*), in which the basal portion of the joints is depressed ventrally, so that in a side view the club has almost a serrate appearance, the fine sense-hairs are confined to the base of each joint, the more raised apical portion of the joint being bare of such hairs. A restriction of these organs to patches has not taken place anywhere in the family.

Setiferous punctures I have not seen.

The sense-bristles are always present dorsally and ventrally, but sometimes very short. The dorsal ones are generally more slender than the lateral and ventral ones, and often concealed under the scaling. On the not-scaled area the bristles stand always in one transverse row; the series is sometimes wholly apical (f. 2, *H. palaemon*); in other species the series is median, but the lateral bristles are more apical (f. 3, *Achlyodes pallida* [1869]), or the series is basal with the lateral bristles median (f. 1, *Ismene iphis* [1773]). In by far the greater number of *Hesperiidae* the lateral bristles are longer than the more mesial ones, and sometimes so long that they can be seen without the help of a lens (f. 5, *Kerama*). The number of bristles is different in the various forms of Hesperids: the highest number observed by me on the not-scaled portion of a joint is 7 (f. 1, 2, *Ismene iphis*, *H. palaemon*), while the lowest number is 2 (f. 5, *Kerama*); the lateral bristles are always developed, though in some cases they are so short that it is not easy to see them; total absence of ventral bristles does not occur. The principal types in the number of bristles, represented in figs. 1—5, are: (1) a complete series of seven bristles; (2) a reduced series of four bristles; (3) a series of three bristles; and (4) a series of two bristles. The difference between the antennae with three and those with four bristles to a joint is very interesting, as the one antenna cannot be derived from the other, the number and position of the bristles thus indicating that each of the two antennae has originated independently from another, probably

from a seven-bristled, antenna. It will be seen from the figures that the bristles stand also in longitudinal rows.

The dorsal bristles have mostly an irregular position, but here and there we find them arranged in an irregular transverse row.

2. *LYCAENIDAE.*

The joints of the stalk are always cylindrical; those of the club, also cylindrical in most species, are sometimes somewhat flattened, especially in the species with abruptly and strongly clubbed antennae. In rare cases (f. 7, *Liptena*) the joints of the club are contracted at base, so that the club has a serrate appearance, especially in a side view. In these latter *Lycaenidae* as well as in those forms which have the antenna abruptly clubbed, the club is often folded longitudinally in **dry** specimens, the ventral wall of the joints having sunk in when drying; this phenomenon does not seem to occur amongst skippers, but is very often met with in thin antennae of other families. The shrinking, as here observed, must not be confounded with the development of grooves of other families: Lycaenid antennae are never grooved. The club is ventrally not more expanded than dorsally, or the difference is very slight.

The scales are on stalk and club either arranged in regular transverse rows, or the serial arrangement is much disturbed. In the extent of the scaling there is a much greater variety than in *Hesperiidae*. According to the space left unscaled, we can arrange the antennae into three groups: (1) Distal or all joints of club ventrally, last one to five joints dorsally, without scaling. (2) The not-scaled ventral area runs down the stalk, sometimes to the base of the antenna; the greater part of the club not scaled dorsally. (3) Like (1) and (2), but the more proximal joints that participate of the ventral bare area have scaling at the apex ventrally, which separates the proximal portion of the not-scaled area into patches; in *Hypochrysops* there is generally one row of scales, while in *Lucia* (f. 6, *Lucia aurifera*) the apical scaling is much more extended.

The not-scaled area is covered all over with fine sense-hairs; it is of great significance that the fine sense-hairs are distributed, not only over the ventral surface, but also over the entire not-scaled dorsal surface (f. 9). In a few of those cases where only the last one or two joints are not scaled dorsally, there are no fine sense-hairs in the mesial line of the dorsal surface (*Liphyra brassolis*). In the species which have the joints of the club narrowed at the base (*Liptena*, f. 7), the hairs are less dense at the apex than at the base of the joints.

The sense-bristles on the not-scaled portion of the antenna are arranged (f. 8) in a transverse series as in *Hesperiidae*, but on the stalk the series is often very irregular. In *Eumaeus* the bristles have also on the club an irregular position. In the forms which have the distal four or five joints entirely without scaling (*Thecla*, f. 9; *Arhopala*), the series of bristles—generally up to eleven in a series—extends all round the joint, so that these joints are of the same form and bear the same organs dorsally and ventrally. The middle joints of the club which are scaled above have a ventral series of seven bristles, as is the case in many *Hesperiidae*; this number seems to be constant, inasmuch as it occurs at least on one joint in all species; to my knowledge there is only one species in which the number is reduced on all joints, that is the aberrant *Liphyra brassolis*. Sometimes the externo-lateral bristle is double, as in many Hesperids. In the species with broad club (*Lycaena*) the lateral bristles are generally longer and thicker than the median ones. The series is mostly median (figs. 8 and 9), seldom apical (f. 7, *Liptena*).

3. *ERYCINIDAE.*

The joints of the stalk are cylindrical, seldom somewhat conical (*Helicopis*); distal joints often flattened ventrally, as are in most species the joints of the club. The not-scaled ventral areas of the proximal joints of the stalk are always convex: those of the distal joints of the stalk are convex, or, as is mostly the case, either flattened in middle or distinctly impressed. The middle of the joints of the club is always flattened or impressed. The impression is often rather deep and well defined, at least proximally; in many cases it has a more or less ovate shape (f. 10, *Necyria saundersi*), while in other forms it is a wide furrow extending from the base to the apex of the joint (f. 11, *Nemeobius lucina*). There is a gradual transition from the not-grooved to the grooved antenna. As in *Lycaenidae*, the club is very often folded longitudinally in cabinet specimens, in which case the grooves of the club are not well visible. As one finds specimens in which the grooves are deeper than in other individuals of the same species, it is most probable that the grooves are more shallow in live specimens than in dried ones.

The scaling, which is rather rough in *Helicopis*, is in most species of great extent. The scales are irregularly arranged on the stalk, but on the club they stand sometimes in regular transverse rows. According to the extent of the not-scaled area, we distinguish the following principal types: (1) The seven apical joints ventrally and the five apical ones also dorsally not scaled (*Taxila* only). (2) Four distal joints not scaled dorsally, a greater number of distal joints not scaled ventrally, the proximal joints of the club and the distal joints of the stalk with small not-scaled middle areas (*Dicalloneura*). (3) Only two apical joints not scaled dorsally, and either only five not scaled ventrally (*Saribia tepahi* [1835]), or there is a ventral middle stripe of variable width extending sometimes down to the base of the antenna, on the stalk very frequently divided up into often small areas in consequence of the scaling encroaching upon the distal portion of the ventral surface of the joints (f. 10, *Necyria saundersi*). (4) Like (3), but the small ventral bare spaces stand at the apex of the joint and extend a little upon the base of the following joint (f. 12, *Helicopis*).

I have not met with a species in which the apical joint is scaled dorsally.

The sense-hairs are distributed over the ventral not-scaled area: in the species with grooves the hairs are not restricted to these grooves, though they are sometimes denser in the groove than without. The length of the hairs varies considerably: the proximal joints of grooved antennae have the hairs often very long. On the not-scaled dorsal surface of the distal joints (one to six) the fine sense-hairs are modified, being very short and placed in punctures: the dorsal and ventral surfaces are, therefore, in opposition to what we found in *Lycaenidae*, different here—the ventral side has a covering of sense-hairs as in that family, while the dorsal side is covered with setiferous punctures.

The sense-bristles resemble in arrangement sometimes those of *Lycaenidae*. There is a transverse series as in that family, extending nearly all round the joint in the few forms where several distal joints are not scaled. The number of bristles in the ventral series on the joints of the club which are scaled above is not constant; the number is mostly reduced, the complete series being seldom met with (*Erycina*; f. 13, *Ancyluris meliboeus*). On the club there is at least one bristle at each side left, while on the joints of the stalk often only the externo-lateral one is preserved (f. 14, *Nymphidium*). In all (?) *Erycinidae* the ventral bristles of the club are

apical (f. 13), the dorso-lateral ones often submedian; on the stalk the lateral bristles stand generally in the middle of the joint, especially regularly in the species with distinct grooves (f. 10, *Neegria saundersi*).

4. *PIERIDAE.*

It has been noticed by Messrs. Godman & Salvin (*Biol. Centr. Amer., Rhop.* II. p. 173) that there are two very different types of antennae in this family, the antenna of the *Dismorphiinae* diverging remarkably and constantly from those of the other Pierid Butterflies. These distinguished Lepidopterists say (*l.c.*) of the subfamily *Dismorphiinae*: "The structure of the antennae presents the greatest peculiarity. Each of the seven or eight joints forming the distal end of the club have four round depressions surrounding their distal edge, which we take to be sensory pits, a structure more complicated than we have yet found in any other group of the *Pierinae*,* though *Terias* possesses a ventral series of similar depressions." There are two inaccuracies in this statement: the *Dismorphiinae* have not four but three sensory grooves to each not-scaled joint, and, on the other hand, the ventral series of similar grooves found in *Terias* is a constantly recurring character of all the *Pierinae* (as opposed to *Dismorphiinae*).

a. PIERINAE.

With the exception of the North American genus *Nathalis*, there is not a single species in this subfamily in which the antennae are without a restricted ventral groove in the middle line of the ventrally not-scaled joints. The groove, which corresponds to the impression found in *Erycinidae*, varies from being circular or almost circular (f. 15, *Colias*; f. 17, *Gonepteryx*) to being a narrow channel which traverses the joint from the base to the apex (*Anthocharis*). Genera like *Stalachtis* (f. 18) and *Nychitona* (f. 19), in which the grooves are very wide, occupying on the club the greater part of the ventral surfaces of the joints, lead over to the antennae of the before-mentioned *Nathalis* (f. 20), which are aberrant in so far as the groove extends over the whole ventral surface of the joint—only the distal joints of the club are not scaled—and that, owing to the great laterad extension, it has lost the appearance of an impression, its lateral borders being very faintly higher than the bottom of the groove. In most *Pierinae* the grooves are deeper on the stalk than on the club, and deeper in dry cabinet specimens than in live individuals. In some cases the grooves on the club are very slightly impressed, but they are always traceable, especially by the fine sense-hairs. These sense-hairs are generally very short and rather broad, having the appearance of minute scales rather than of hairs, and stand closely together in the groove, forming often a rounded silvery patch.

The sense-hairs are restricted to the grooves, a character by which *Pierinae* are well distinguished from *Erycinidae*. The grooves seldom occupy the whole of the not-scaled ventral area of the joints; the remainder of this area is covered with setiferous punctures, which are likewise found on the not-scaled dorsal surface and are especially conspicuous in forms with nearly naked antennae (*Mesapia*, figs. 21, 22).

* The *Pierinae* of Messrs. Godman & Salvin, who treat these Butterflies as a subfamily of *Papilionidae*, are our *Pieridae*.

The sense-bristles of the ventral surface are not very conspicuous, being mostly short. Though from some species the bristles are almost entirely absent (f. 17, *Gonepteryx*), and in others there are obvious bristles only on some of the joints, in by far the greater percentage of *Pierinae* we find regularly a lateral pair standing about in the middle of the joint and an apical pair of more mesial position (figs. 16, 19, 23): besides the regular pair of lateral bristles, there are on the joints of the stalk mostly some more lateral ones of variable position, forming sometimes (*Leptosia*) a nearly regular transverse series. The dorsal bristles are in the few species with sparse scaling (*Mesapia*, f. 21) very strong also on the stalk.

In the extent of the scaling the antennae present the following types: (1) The whole dorsal surface scaled, inclusive of the last joint; a ventral median stripe extending from the apex down the stalk for a variable distance not-scaled (*Gonepteryx*, f. 17; *Phulia*), or the not-scaled area restricted to the club (*Nathalis*). (2) The last one (in very many species) to four (seldom, some *Eurema* for instance) joints not scaled dorsally; a ventral not-scaled stripe down the stalk for a variable distance. (3) Like (2), but the joints of the stalk scaled at apex (f. 24, *P. brassicae*), or at base and apex. (4) The scaling sparse, almost confined to the external side of dorsal surface (figs. 21, 22, *Mesapia*).

The formation of the club of *Pierinae* furnishes often good characters for the distinction of genera. To give an instance, I have figured the apical joints of the antennae of some species of *Eurema*, under which generic term a variety of different forms are united by most authors. In the American species with rounded hindwings (f. 25, *E. albula*) the apical joint of the antenna is free, not fused with the preceding one, longer than broad; the following joints are broader at the apex than at the base, so that the club has almost a serrate appearance; the grooves are long and reach the apical edges of the joints. In the American species with angled hindwings (*E. bogotana*, f. 26) the last two joints are fused to one, which bears two grooves, and the following joints are as broad at the base as at the apex; the grooves are smaller than in *E. albula* and allies, but are continued nearly to the apical edges. The species of the Eastern Hemisphere have the apical joint free like *E. albula*, but very short (f. 27, *E. hecabe*); the following joints are slightly narrowed at the base, but not so much as in *albula*; the grooves are small and rounded as in *bogotana*, but do not reach the apices of the joints.

The aberrant Pierid of which the last joints of the antennae are represented by f. 28 is *Pseudopontia paradoxa*; the antenna of this species has twenty-seven joints only, and there is no indication of the formation of a club; the joints are basally and apically narrowed; the grooves are large and very distinct; at the apical edge of the groove the pair of bristles is visible which is normal for most *Pieridae*.

b. DISMORPHIINAE.

The last two joints are always merged into one, which is often nearly as long as the two following ones together (*Dismorphia orise*). Besides this "apical joint," two more (*Leucophasia sinapis*) or a greater number of joints of the club are not scaled, while the rest of the antenna is always scaled all over. The highest number of joints that are bare of scales ventrally is thirteen, the not-scaled area never extending down to the stalk, being always confined to the club. Dorsally the scaling is a little more extended than ventrally, the one or two proximal joints that participate of the bare area being scaled above. The sexes differ sometimes obviously in the

extent of the scaling: in the ♀ of *Leucophasia gigantea*, for instance, the seven distal joints are not scaled, while in the ♂ the bare area occupies only five joints and extends (ventrally) a little upon the sixth.

Each not-scaled joint has, instead of the single median groove of the *Pierinae*, in all the species three grooves standing always at the apical edge of the joint, one mesial and one on each side (f. 29, *Leucophasia sinapis*: f. 30, *Dismorphia thermesia* [1819]). The grooves vary very much in size in the different species; the middle one is always the largest: sometimes there is a small puncture-like additional groove at each side (f. 29). The apical joint (consisting of two fused joints) bears two transverse rows of grooves (figs. 29, 31); the lateral ones extend much upon the dorsal side, appearing sometimes nearly dorsal. Extremes in the size of the grooves are represented by *D. orise* (1836) and *D. eumelia* (1782); in the former species the grooves are small, rounded, and widely separated, while in *eumelia* (f. 31) and allies the lateral ones extend along the apical edge of the joint reaching the mesial groove.

The fine sense-hairs are restricted to the grooves. The rest of the not-scaled area is covered with setiferous punctures, except in the middle of dorsal surface.

Of the sense-bristles there are generally two pairs developed, the two bristles of the first pair standing at either side of the mesial impression, sometimes followed by a second pair (f. 31), and the other pair being lateral, standing at the proximal edge of the lateral grooves (figs. 29—31). The *Dismorphiinae* have, therefore, the same regular bristles as the *Pierinae*.

5. *PAPILIONIDAE*.

The structure of the skeleton of the antennae is in this family very coarse (see Bodine, *Tr. Amer. Ent. Soc.* 1896. t. 4. f. 39). The extent of the scaling and of the fine sense-hairs is very different in the various members of the group; the latter are, however, always restricted to the ventral surface. The configuration of the ventral surface and the number and position of the ventral sense-bristles exhibit also diverse development in the various Papilionids.

a. PAPILIONINAE.

The antenna is generally somewhat compressed laterally; the distal joints are mostly more expanded ventrally than dorsally, so that the club is curved dorsad. In most forms the joints are somewhat broader at the apex than at the base. The ventral surface is sometimes almost evenly convex, without impressions (f. 38, *Leptocircus*; f. 36, *Papilio agamemnon*), but is often depressed or subimpressed laterally (in the species allied to *Papilio machaon*, *memnon*, etc.); in a great many Papilios (in all so-called "*Ornithoptera*," then in *P. hector*, *philoxenus*, *sesostris*, etc., belonging to Haase's subgenus *Pharmacophagus*, in *Eurycus* and *Euryades*) there is at each side of the ventral surface a more or less elongate groove (f. 40, *Papilio philoxenus*) which is deeper on the stalk than on the club. A similar groove is found in certain Papilios allied to *P. podalirius* (f. i. in *P. leosthenes*), but here the grooves are generally less well defined and stand nearer the median line of the joints. The interspace between the two grooves is never carinate, as it is in the *Nymphalidae*.

The fine sense-hairs, restricted to the ventral surface, are distributed as follows:

(1) All the joints are covered with sense-hairs from the base to the apex ventrally (f. 41, *P. ambrax* ♀). Such a distribution does not occur in *males*, it being a character confined to the *female* sex, especially of sexually dimorphic and dichromatic species (*P. ambrax*, *memnon*, *merope*, etc.). (2) The not-scaled area of the stalk is covered with fine sense-hairs (f. 38, *Leptocircus*), but on the joints of the club the sense-hairs are restricted to the base of the joints (f. 39, *Leptocircus*). (3) The sense-hairs occupy the basal half or more of the joints; the hairy area is mesially a little more extended than laterally (f. 36, *P. agamemnon*). This type appears in the species of Haase's subgenus *Cosmodesmus* (*P. macareus*, *ajax*, *podalirius*, etc.). (4) The hairs restricted to the basal portion of the joint as in (3), but the hairy area deeply sinuate in the middle line (f. 42, *P. ambrax* ♂), often divided into two patches. (5) The hairs restricted to the lateral grooves (f. 40, *P. philoxenus*) in all the species which have such grooves.

The sense-bristles resemble sometimes in arrangement those of certain *Hesperiidae* and *Lycaenidae*, but are mostly much more irregular in position. A nearly regular series of bristles is found on the joints of the club of *Leptocircus* (f. 39, lateral view); an indication of a transverse series we met with in *P. agamemnon* and some allies (figs. 36, 37). A lateral pair of bristles is found in nearly all species (figs. 36, 42), and there are also generally some subapical ones. In the species with grooves we observe here and there some bristles between the two grooves (f. 40).

The scaling is most extended in *Leptocircus*, where it covers the whole dorsal surface, except the last joint, and occupies also a great portion of the lateral and ventral surface, there being on the stalk only a middle stripe left bare of scales, and this stripe being moreover interrupted at the apices of the joints (f. 38). In Haase's subgenus *Cosmodesmus* (*P. podalirius*, *ajax*, *leonidas*, *macareus*, etc.) the antennae are also scaled (f. 37), but the scaling is restricted to the dorsal surface and is not very dense : the scales are rather small, generally only two-toothed, and fall off easily, especially on the club. The third type of antenna in respect to scaling is represented by the subgenera *Pharmacophagus* and *Papilio*, all the species of which are without scaling on the antennae (the basal joints excepted).

The space not occupied by scales or fine sense-hairs bears a dense covering of setiferous punctures. The dorsal surface is generally without punctures in the median line; but in the *females* (not the *males*) of *Papilio priamus* and allied forms the median area is punctured: the difference in the two sexes in this respect is of significance, as we shall see later on.

b. THAIDINAE.

The joint is somewhat wider at the apex than at the base; its ventral surface is generally more or less depressed at both sides of the mesial line. In most species there are no grooves (f. 43, *Armandia*), while in *Sericinus* (f. 44) we find a small groove at each side ; in some specimens of *Luehdorfia* the joints of the stalk are rather obviously impressed at each side, but the impression is not so well defined as in *P. polyxenes* and mostly only indicated (f. 45, *Luehdorfia japonica*).

The fine sense-hairs are distributed over the greater part of the ventral surface (*Sericinus*), but are always denser at the base than towards the apex of the joint; or they are restricted basally, especially on the club, being at the same time more extended distad at the sides than in the middle (*Luehdorfia*).

The sense-bristles of the ventral surface have an irregular and variable position : on the joints of the club we find here and there an irregular transverse series of apical bristles, while mostly there are only some lateral bristles developed (figs. 43, 44, lateral views). Dorsally the bristles of *Luehdorfia* are long and strong (f. 46).

The antennae are always without scaling, except on the most proximal joints ; but in *Sericinus* we find some very long hair-like scales scattered over the dorsal surface.

Setiferous punctures are numerous, especially at the sides of the joints.

c. PARNASSIINAE.

The joints of the antennae, which are more or less compressed, are of two different types connected by intergradations. (1) The ventral surface is without groove, and the fine sense-hairs are distributed over the basal area of the joint. (2) The joint has an impression of irregular shape (figs. 33, 34) : the groove is sometimes nearly as regular as in *Pieridae*, but it is a rule that the grooves on the joints of the same antenna are different in shape and size (f. 34) ; on the club the groove is always very irregular, often divided into several branches (f. 32) ; the fine sense-hairs are restricted to the grooves, if these are large enough. The most important point is, that antennae **with** and **without** grooves occur in the same species, as an examination of a series of specimens of *P. apollo* from one locality proves. The groove on the joints of the stalk is not mesial, but has a more exterior lateral position than in *Pieridae*.

The sense-bristles are ventrally not well developed and of no regular distribution ; but on the dorsal side of the joints they are long and strong, on the scaled as well as on the not-scaled joints (f. 35).

Setiferous punctures are very numerous, and there is scarcely a line of distinction between the fine sense-hairs and the hairs situated in these punctures.

The scaling is mostly dense and rather much extended. It occupies the dorsal surface from the base to the apex (*P. simintheus*, *rhodius*) ; in some species the stalk is also fully scaled ventrally, except some distal joints ; but very often the whole club is not scaled dorsally, and the ventral surface of the club and of most joints of the stalk is also bare of scales. In a few forms the scaling is very scanty, the antenna appearing almost not-scaled (*stubbendorfi*).

6. *NYMPHALIDAE.*

Under this family term I unite, in accordance with the views of many Lepidopterists, all the Butterflies which do not belong to any of the preceding families : *Hesperiidae*, *Lycaenidae*, *Erycinidae*, *Pieridae*, and *Papilionidae*. But, by thus treating *Libytheinae*, *Satyrinae*, etc., as subfamilies of *Nymphalidae*, I do not wish to state as my opinion that these groups of genera will have subfamily, not family, rank in my final classification of Butterflies. So much, however, is certain, that all these Nymphalid Butterflies are, in respect to the antennae, much closer allied between themselves than with any other Butterfly, and that I am therefore perfectly justified in treating here the now following groups of Butterflies as one great section remarkably different from all the preceding families.

The Nymphalid Butterflies, without exception, have two ventral grooves to each not-scaled joint, one at each side of the median line. The fine sense-

hairs are restricted to these grooves. In the size and shape as well as in the position of the grooves there is a great variety, but they are never entirely absent, though on the club sometimes only slightly marked. The ventral median line is cariniform, and there are, at the external side of the grooves, two more carinae; only in a very few forms the carinae become obsolete. The ventral sense-bristles are surprisingly regular in position, though they are sometimes obliterated; there is a basal pair of bristles, close to the median carina, and a lateral pair at the external side of the grooves, which is median, basal, or apical in position. The scaling varies in extent more than in any other family; many species have no scales on the antennae, the greater proportion of *Nymphalidae* has the ventral surface not scaled, and in numerous species the not-scaled area is restricted to the distal joints. The setiferous punctures are rather coarse at the sides of the antennae without scales, or of such which have only the dorsal surface scales.

a. CALLINAGINAE.

The scaling is confined to the dorsal side of the proximal joints. The scales are very narrow, resembling those of *Luehdorfia* and certain *Parnassius* (*stubbendorfi*). Ventrally each joint has the mesial line raised to a distinct carina (f. 47). Laterally there is an oblong, very deep, impression: the two impressions are far apart: in the figure, which gives a ventral view of the joint, the grooves appear much too narrow. The fine sense-hairs are equally distributed over the grooves. Rest of ventral surface and sides beset with setiferous punctures. Close to the mesial edge of each groove, not far from the base of the joint, there stands a sense-bristle: a second pair of bristles is situated laterally at some distance from the dorsal raised edge of the grooves between the middle and apex of the joint.

b. PSEUDERGOLINAE.

Like the preceding subfamily, the present one contains only one genus. Though I do not think that it is correct to keep *Pseudergolis* separate from the *Nymphalinae* on account of the development of the forelegs of the *female*, I describe here the antennae separately merely for the sake of convenience.

The antenna is scaled dorsally; ventrally the joints are bare of scales, except the most proximal ones. Each joint has two ventral grooves extending from the base to the apex of the joint, of nearly equal width throughout (f. 48). The grooves are close together, separated only by a sharp high median keel; laterally the grooves are also limited by a distinct carina. The fine sense-hairs are evenly distributed within the groove. Each groove has a sense-bristle basally at the sloping side of the median carina. A second bristle stands laterally beyond the middle of the joint between the lateral carina and the scaled portion of the joint.

c. LIBYTHEINAE.

The scaling is restricted to the dorsal surface of the antenna: it extends either to the very tip of the antenna (f. 49, *L. celtis*), or the last joints are not scaled (f. 50, *L. antipoda*). The scales are mostly three- or four-toothed. The naked ventral area has three carinae, including between themselves two grooves which reach from the base to the apex of the joint (f. 51). On the proximal joints of the stalk the inner groove is narrower than the outer one (f. 51), as is the case in

many *Nymphalidae*. The fine sense-hairs are distributed over the whole groove. There are two pairs of ventral bristles—a basal one, often very short, and a lateral pair which is median or submedian. The not-scaled sides of the joints are beset with setiferous punctures.

The tip of the antenna is in *L. celtis* (f. 49) remarkably different from that of the other species of *Libythea* (f. 50), being much less expanded ventrally, and hence much less curved dorsad.

d. ACRAEINAE.

According to the extent of the scaling of the antennae, the *Acraeinae* can be divided into three groups. The first group contains the species allied to *punctatissima* (1833), which have the antennae densely scaled all over, except the whole last joint and the ventral surfaces of the preceding nine joints. The second group comprises *A. vesta* and American species, in which the scaling is restricted to the dorsal surface: the scales are narrow, not dense, towards the apex of the antenna even scarce, but are always present on all the joints except the last one. To the third group belong most Eastern species and the bulk of the African species of *Acraea*; in these species only the joints of the stalk bear sparse, very narrow and short scales dorsally. The scales of the first and second group are dentate at the apex, and hence very different from the scales of the wing (except edge) and abdomen.

On the not-scaled ventral area of each joint there are two deep impressions which become shallow towards the middle carina, so that the two more impressed portions of the grooves are rather widely apart. The middle portion of each groove is more suddenly impressed again, so that it appears as if there was a groove within another. The not impressed middle part of the joint is either rather broad, especially on the club, bearing a raised middle line, or forms a narrow and sharp carina. The width of the grooves is different in the various groups of *Acraea*; those of the stalk are especially wide and deep in American species.

The sense-hairs are more or less evenly distributed over the impressed portion of the surface of the joint, or are confined to the bottom of the groove, forming a rounded patch, which is sometimes divided into two patches (*A. moluccana*, f. 52). The median and lateral, not impressed areas are beset with setiferous punctures, of which the hairs are sometimes (*A. moluccana*) so long that nearly the whole not-scaled ventral area appears to be covered with sense-hairs.

A pair of basal, admesial, and a pair of lateral bristles. The basal ones are often very short and generally less obvious than the lateral bristles.

e. HELICONIINAE.

The ventral surface of the antenna is always devoid of scales. The dorsal side is densely covered with very narrow, bidentate, scales up to the last joint in *Eueides*, while in *Heliconius* the scaling is on the distal half of the antenna either very sparse or absent. The three ventral carinae are high on the stalk as well as on the club; the grooves between them deep, extending from the base to the apex on all joints (f. 50).

The fine sense-hairs stand somewhat denser in the basal than in the apical portion of the groove, but are never restricted to a small patch. The joints of the stalk bear in the groove either one basal pair of bristles only, or there are two more pairs (f. 50), one median, the other subapical. In many species these additional

bristles are found only on the proximal joints. The lateral pair of bristles found in all Nymphalids stands rather close to the base on the joints of the stalk (f. 50). On the club there is only one basal, admesial, pair of bristles, and the lateral pair stands between the base and middle of the joint. In a dorsal view (f. 51) of the antenna we observe, besides the ventro-lateral pair of bristles, a second dorsal pair just behind the middle of the joint. The sides of the joints are rough with setiferous punctures.

f. SATYRINAE.

Though this group is not so large as regards number of species as the *Nymphalinae*, there is a greater variety in the development of the antennae than in that subfamily, and I have no doubt that the extent of the scaling, the length and position of the bristles, the structure of the last joint or joints of the club, as well as the development of the carinae and grooves, will one day be of great use in the classification of these Butterflies.

In regard to the scaling there are five principal types to be distinguished :—

(1) The scaling occupies the whole dorsal surface except the last joint; the ventral side is also scaled with the exception of the distal or all joints of the club. In *Triphysa* (*phryne*, *dohrni*) the not-scaled area is restricted to four joints.

(2) The scaling is extended as before, but the ventral side of the club and small spaces on the distal joints of the stalk, not reaching the apex of the respective joint, not scaled (f. 55, *Ep. janira*). A very common type.

(3) Dorsal scaling as before, but the ventral not-scaled area running down the stalk to (about) the fifth proximal joint, not interrupted by scaling (*Satyrus dejanira*).

(4) Ventral scaling as before, but the apical half of the club (or more joints) not scaled dorsally (*Lethe*).

(5) Scaling absent (except the most proximal joints). This type is comparatively rare (*Pierella* and allies).

According to the great divergency in the structure of the not-scaled ventral surface, the antennae of *Satyrinae* can be classified into four groups (none of which correspond with the above five groups) :—

(1) The ordinary type, met with in by far the greater number of *Satyrinae*, has three carinae, between which are two grooves as in other Nymphalid Butterflies. The carinae vary much in height, are generally simple, but are in *Pierella* (only) finely serrate as in *Brassolinae*. The internal—upper—groove is on the stalk nearly always narrower than the external one (f. 55, *E. janira*), and is in most *Satyrinae* developed only on the distal joints of the stalk (and on the club), in which case the more proximal joints of the stalk appear to be one-grooved and remind one very much of the single-grooved antennae of *Pierinae* and *Erycinidae*. However, the median carina becomes plainly visible, if one removes the scales, and in many forms the vestige of the second groove will be found under the scaling. The position of the single groove is not altered, it being placed (f. 55) exactly like the external groove of the two-grooved joints, *i.e.* is more external than the single groove of *Pierinae* and *Erycinidae*. The fine sense-hairs are either distributed all over the grooves (f. 56, *S. dejanira*), or stand in a patch (f. 55, *E. janira*). There are two pairs of sense-bristles, a basal pair situated in the grooves, and a lateral pair, which is either median or subapical; the basal pair is sometimes obsolete. On the not-scaled dorsal side of the apical joints we find two bristles in many species (f. 60, *Taygetis erubescens*). *Taygetis chrysogone* (1851) is

aberrant in having in the outer groove of the proximal joints as well as on the dorsal surface of the not-scaled apical joints a great number of erect fine hairs ; in this character *T. chrysogone* differs obviously not only from the other species of the genus, but from all other *Satyrinae*, so far as I know. The apex of the last joint has in many *Satyrinae* a rather large number of long bristles, while in other species these bristles are short and few in number.

(2) The second type is represented by *Sinchula* (f. 57). The grooves are here reduced to somewhat rounded dimples which stand widely apart. The median carina, though feeble, is nevertheless developed. The fine sense-hairs are restricted to the grooves. Two short bristles near the inner edges of the patch of sense-hairs correspond to the ventro-basal pair of bristles of the first type. The lateral pair of bristles is well developed.

(3) The third type is met with in *Ipthima asterope* (f. 58). Here the grooves are still more restricted than in the second type, and stand near the apex of the joint; they bear fine sense-hairs, while the rest of the ventral surface is densely beset with setiferous punctures. The lateral pair of bristles is subapical; the ventro-basal pair is obsolete. The median carina is not developed. Other species of *Ipthima* have the antennae of the first type.

(4) The fourth and most simplified type occurs in *Triphysa* (*dohrni*, f. 59), peculiar insects found in Central Asia. The grooves as well as the carinae are absent; but the fine sense-hairs, which are few in number, stand in two patches corresponding in position to the grooves of other Nymphalid Butterflies. At the inner border of each patch a short bristle is visible, which is homologous to the ventro-basal pair of other *Satyrinae*; the lateral pair is also developed, but the bristles are short.

g. BRASSOLINAE.

The antenna is either scaled dorsally from the base to the apex (*Neropc*), or is not scaled except at base (*Caligo*, *Brassolis*). The three ventral carinae are developed, and in all species finely but obviously serrate. In respect to the structure of the joints the two principal types are represented by *Brassolis* and *Caligo*.

In *Brassolis* (f. 61) the joints have the three carinae strongly developed on the stalk; the grooves between them are deep for their entire length (the apical edge only of the joint not being impressed); on the club, however, the carinae are very feebly raised, and the impressions between them are so shallow that one can scarcely speak of grooves. The grooves on the stalk bear only a very few sense-hairs, situated near the base of the joint. Of the ventro-basal pair of sense-bristles only one is visible and that is more obvious only on the joints of the club, while the lateral pair of bristles of other Nymphalids is also in *Brassolis* plainly visible. The joints bear dorso-laterally very few setiferous punctures, and are of a very smooth appearance.

In *Caligo* (f. 62) the carinae are as high on the joints of the club as on those of the stalk, and the grooves between them are deep both on club and stalk. As the grooves extend to the very edges of the joints, and the carinae are high throughout their length, the apical margin of each joint is deeply bisinuate. The grooves bear sense-hairs from the base to the apex, but the hairs are more densely set at the base of the joint. Dorso-laterally the joints are rough with setiferous punctures. A pair of short ventro-basal bristles, and a lateral pair, situated between base and middle on the joints of the stalk, are present.

h. MORPHINAE.

In most genera the antennae are bare of scales, while in some (*Discophora*) the dorsal surface, with the exception of the club or part of it, is covered with scaling. Ventrally there are three carinae, which are not serrate as in *Brassolinae*; the carinae are high on stalk and club, but in some forms (some species of *Tenaris*) they are not well marked on the distal joints. The grooves between them extend from the base to the apex of the joint. The fine sense-hairs are either nearly equally distributed over the groove (f. 63, *Tenaris bioculatus*), or are rather sparse, forming generally two patches, a basal and a subapical one, in each groove (f. 64, *Discophora*). The bristles are mostly rather conspicuous; in *Tenaris*, *Hyantis*, and allies they are mostly very long. Besides the ventro-basal pair there is sometimes a second pair in the grooves of the stalk, standing in or beyond the middle of the joint. The lateral bristles of the stalk are subbasal, on the last joints of the club they are more median, and in certain *Tenaris* even apical. Sides of antenna coarsely punctured.

i. NYMPHALINAE.

This group, containing the greater number of species of Nymphalid Butterflies, offers great diversity in minor points. The antennae can be grouped according to the development of the scaling as follows: (1) Scaling dense; the ventral surface of the club, and, besides, the dorsal surface of the last two joints, not scaled (*Chersonesia*, *Phyciodes*). (2) Scaling as extended as before, but the distal joints of the stalk have each a bare basal space, reminding one of the not-scaled spaces found in certain *Lycaenidae*, *Erycinidae*, and *Pieridae* (f. 65, *Araschnia*). (3) Scaling restricted to the dorsal surface; last two or more joints (at the highest about half the club) not scaled dorsally. Here belongs the bulk of the subfamily. (4) Scaling absent (the most basal joints excepted); a rare type (*Prothoë*).

The scales are generally rather broad, two- or three-toothed, but in some cases (*Charaxes*) they are short and narrow.

There are always three carinae marked on the ventral side, varying in height considerably in the different forms of *Nymphalinae*. In *Euresia*, which has only the ventral side of the club not scaled, the carinae are feebly developed. The grooves between the carinae extend from the base to the apex of the joint in those forms where the ventral side of the joint has no scaling, but are on the club sometimes very shallow and often broader than long. The fine sense-hairs are either evenly distributed over the groove (f. 66, *Parthenos*; *Dione*), or are gathered together in an elongate or rounded patch (*Vanessa*, f. 67). Normally there are present a ventro-basal pair of bristles, as well as a lateral pair which is subbasal or median, but on the club sometimes subapical or apical (*Romalaeosoma*). The sides of the antennae are densely punctured.

k. NEOTROPINAE.

The squamiform structure of the skeleton of the joints is in this group generally finer than in most other *Nymphalidae*. In the shape of the joints there is a rather great diversity among the *Neotropinae*.

The scales are rather loose and fall off easily. The scaling is restricted to the dorsal surface; it reaches in many forms to the middle of the club, but in others it is confined to the basal half of the stalk.

The three carinae are high; the impressions between them vary in depth, width, and outline. The fine sense-hairs are seldom distributed over the greater portion of the groove; they form mostly a rounded patch, of often small size (figs. 68—70).

There is a ventro-basal pair of bristles, and a median or postmedian lateral pair. On the dorsal side of the not-scaled joints we observe, besides, another pair of bristles (f. 70), which is always subapical or apical on the club. In many species allied to *Ithomia*, especially in *Hyposcada*, the not-scaled joints have a number of additional dorsal and dorso-lateral long bristles. The sides, sometimes the whole dorsal surface (if not scaled), are beset with setiferous punctures. Dorsally the joints are in the mesial line often somewhat impressed; in *Hamadryas* there is dorsally an almost complete mesial furrow along the not-scaled portion of the antenna.

l. DANAINAE.

All the species of this subfamily have the antennae bare of scales, as has already been observed by Scudder,* who, however, unites the *Neotropinae* with scaled antennae with the *Danainae*. The three carinae are always developed, but in some forms not so strongly marked on the club (f. 71, *D. plexippus*) as in most species. The grooves are on the joints of the stalk basally much more shallow than in the middle of the joint. The fine sense-hairs are always restricted to a rounded patch, which is very conspicuous (f. 72), especially in species with dark antennae, on account of the silvery hue of the short hairs, and is more impressed than the rest of the groove.

The ventro-basal and the lateral, subapical or median, pairs of sense-bristles, generally well developed, are in some cases (*Danais*) obsolete. Dorsally (f. 73) there is regularly a postmedian pair of bristles present, besides one or more bristles which appear occasionally on one or the other joint without regularity.

From the descriptions of the antennae of the families of Butterflies given in the foregoing pages, we learn that an antennal organ or structure is variable in one family, while it is relatively constant in other groups. Among the *Papilionidae* we find species with not-scaled antennae and such with an extended development of antennal scaling, while in the *Hesperiidae* and in the *Dismorphiinae* the not-scaled area is constantly restricted to the distal joints. The *Nymphalidae* have a ventro-basal and a lateral pair of bristles in all the members where the bristles are developed, and the *Hesperiidae* have always a transverse series of bristles (sometimes reduced to two); while the various members of *Papilionidae* deviate in this respect widely from each other. The *Hesperiidae* have never grooves; the *Pierinae* have always one, the *Dismorphiinae* always three, the *Nymphalidae* two; while the *Papilionidae* have one, two, or no grooves. And a similar variability in some and constancy in other groups is found in respect to the fine sense-hairs. It is obvious that the families in which a certain antennal organ or structure shows different stages of development in the various members will most likely present us also with such stages as will reveal to us, firstly, the line of development by which other families, in which that organ or structure is uniform in type, have arrived at their stage of development, and hence show us, secondly, the phyletic connection between the various groups of Butterflies. Before, however, entering upon these questions,

* *L.c.* p. 115.

it is necessary to give a review of each antennal organ and structure that we have described above, taking into consideration, not only the antennae of Butterflies, but also such chief stages of development of these organs as I have met with among Moths, in so far as these stages are of importance for our present purposes.

a. **The Scaling.**—The number of Lepidoptera which have not-scaled antennae is very small in comparison with the number of species that bear scaling at least on the dorsal surface of the stalk, and even the antennae which I call not-scaled have in many cases the most proximal joints sparsely scaled above. Among Heterocera I have found not-scaled antennae only in a few families. The Eastern *Hepialidae* have mostly the antennae bare of scales, while in most American species (all?) the dorsal side is scaled to a more or less great extent. The *Saturniidae*, inclusive of *Ceratocampidae*, have not-scaled antennae, with the exception of *Draconipteris*, *Teratopteris*, and *Oxytenis*, which, in my opinion, are not Saturniids. The genus *Amerila*, which stands rather isolated among the Arctioid Moths, has also not-scaled antennae. Whether there are any *Tineidae* that belong here I do not know; all the species I could examine have the antennae scaled. The proportional number of species without scales on the antennae (except the three to six basal joints) is by far larger among Butterflies: but here again such antennae are not found in members of all the families, but are confined to the *Papilionidae* and *Nymphalidae*, not a single species of *Hesperiidae*, *Lycaenidae*, *Erycinidae*, or *Pieridae* having the antennae not-scaled. The absence of scales is a constant character in several groups of *Papilionidae* and *Nymphalidae* (*Thaidinae*, *Danainae*), while in other groups of these families the character occurs only in a very restricted number of species (some *Parnassius*, *Morphinae*, *Satyrinae*, etc.). In a few *Pieridae* (*Mesapia* and allies) the scaling is very sparse, but not absent.

Is the not-scaled antenna the one extreme in the development of the scaling, the totally scaled antenna would be the other extreme. However, there is not a single Lepidopteron in which the entire surface of the antenna is covered with scales. In every species there is a space, varying in extent in the different species or groups of species, left bare of scales, a space bearing sensory hairs; and this not-scaled area is either entirely restricted to the ventral surface of the antenna,* or, if the dorsal side participates of it, its ventral extent exceeds the dorsal extent. In no case is the ventral side all scaled and the not-scaled space restricted to the dorsal side, nor is the area more extended dorsally than ventrally; and again, if the not-scaled area extends upon the dorsal surface, it is always the distal portion of the antenna that is without scaling; it never occurs that the apical joints are scaled above and the more proximal joints are bare of scales.

There is a series of intergraduate stages between the not-scaled and the **almost** (!) completely scaled antenna in Butterflies.

Among Moths I have not come across such intergraduate stages, except in *Hepialidae*, where the antennal scaling, if present, varies from occupying the entire dorsal surface to being restricted to the proximal half or third. In all other Moths the dorsal side of the antennae is scaled, inclusive of the last joint; in species with long pectinations the branches are, however, often bare of scales. Such a great extent of the dorsal scaling as found in the Heterocera (except the few forms without antennal scaling, and certain *Hepialidae*) is not so often met with among

* The not-scaled area is not in the middle of the ventral surface, but is interno-ventral; in the antennae with dark upper- and pale underside the line of demarcation between the two colours is often rather sharply defined.

Rhopalocera. Here the last one or two joints, at least, are not scaled as a rule; but there are in all families (except *Papilionidae*) instances of the dorsal surface being entirely scaled, and it is especially worthy of note that this extended development of the scaling is found in all *Hesperiidae*. The scaling of the ventral side is in the larger number of Butterflies restricted to the most proximal joints, a more or less broad ventral stripe being bare of scales; in the species with more extended ventral scaling the proximal restriction is preserved in so far as the not-scaled portion of the antenna is always (without exception) distal, the last joints being ventrally never scaled. The not-scaled ventral area is extremely variable in extent in the different forms of Butterflies. In all families, except *Hesperiidae*, we find the area restricted to the last joints or extending down the stalk, often to the base, without regularity as regards a whole family. But within the families we find very often groups of genera in which the extent of ventral scaling shows an obvious constancy. The *Papilioninae* and most subfamilies of *Nymphalidae* have no ventral scaling, while in *Parnassiinae*, *Nymphalinae*, *Satyrinae*, *Acraeinae*, as well as in *Pierinae*, *Erycinidae*, and *Lycaenidae*, the ventral scaling is sometimes restricted (or absent), sometimes extended to the club. A constantly very extended development of the ventral scaling we observe in *Hesperiidae* and *Dismorphiinae*; in all the species of these groups the not-scaled area is restricted to the club, never extending down upon the joints of the stalk. Those *Nymphalinae* and *Satyrinae* which have the not-scaled area restricted to the last joints are generally small, weak-bodied, species; at least, if of two allied forms one is Hesperioid in the development of the scaling and the other has the bare area extending down the stalk, the first is the smaller one; while, on the other hand, the species without antennal scaling are generally stronger in body or larger than their near allies which have the antennae scaled.

In Heterocera ventral scaling is found in proportionally very few species, occurring only in some of those forms which have clubbed antennae like Rhopalocera, and in those *Pyralidae* and *Tineidae* which have very long and slender antennae. In *Castniidae* the ventral side is either without scaling, or the not-scaled area is restricted to the club and some of the distal joints of the stalk: in *Sesiidae* the bare area is similar in extent, but here the distal joints of the stalk and the proximal ones of the club have a transverse series of scales at the apex, as is the case in certain *Lycaenidae* (*Hypochrysops*). In both those Heterocerous families the scaling is in extent of a Rhopalocerous type, the bare area being distal. In the species of Heterocera with very long antennae (*Chimabache*, for instance) the distal portion of the antenna is scaled all over, the not-scaled area being thus restricted to the proximal half of the organ; in many cases this sense-hair-bearing portion of the antenna is still more restricted, each joint having an apical transverse series of scales. I have not found any species with filiform or setiform antennae (inclusive of pectinated ones) in which the not-scaled area is distal, as in clubbed antennae. It is evident that there must be some connection between the development of a club and the restriction of the not-scaled surface to the distal joints.

b. **Fine Sense-Hairs.**—The antennae bear two kinds of sense-organs, fine sense-hairs and setiferous punctures, which are restricted to the not-scaled portion; their extent depends, therefore, to a certain degree upon the development of the scaling. The fine sense-hairs are either found on the ventral surface only, or they occur ventrally and dorsally. The latter type is very rare: we meet with it among *Hepialidae*, of which a number of species have all the ventral and dorsal surface

that is not covered with scales densely beset with long fine sense-hairs, dorsal and ventral side of the antenna being alike in this respect (as well as in other characters). No Frenate Heterocera have fine sense-hairs dorsally. Among Butterflies, however, we find them again on the dorsal side, and this fact is of high significance, all the distal joints that are not scaled above of certain *Lycaenidae* (*Arhopala*) being equally covered all over with fine sense-hairs. No members of other Butterfly-families have this character.

In the remainder of the Lepidoptera the fine sense-hairs occur only ventrally; such a type we find also among *Hepialidae*, besides the first type. The Heterocera without exception, as far as I know, have the not-scaled ventral area covered all over with these hairs, inclusive of the branches of pectinated antennae; the hairs are, however, often of different length on the same joint. Such a uniform distribution of the fine hairs obtains among Rhopalocera in all species of *Hesperiidae* and *Lycaenidae*, and in the *females* (not *males*) of certain Papilios (*polytes* and allied forms). In all the other Butterflies the hairs are restricted in extent. In *Erycinidae* the restriction is only indicated by the hairs being sometimes denser in the impressed middle of the joint than laterally: in *Pierinae* we have a further step in the same direction, the hairs being in this subfamily of *Pieridae* restricted to a middle groove, while in *Dismorphiinae* the hairs are placed into three grooves. The *Papilionidae* with restricted extent of sense-hairs present three different types: in the first the hairs are confined to the base of the joint, forming one more or less large patch, which is often deeply sinuate in the middle; in the second type the hairs are placed in an irregular groove (*Parnassiinae*); while in the third type the hairs are restricted to two grooves, standing at each side of the mesial line or being more lateral. This latter mode of distribution is constantly found in all the species of *Nymphalidae*, where the restriction is carried often so far that there is only a small round patch of short hairs (*Danainae*, for instance) in each of the two ventral grooves we find in this family; sometimes only a few sense-hairs are present (*Brassolis*, *Triphysa*). It is a general rule that, within the same group of genera, the fine sense-hairs are longer in the species where they are less restricted in number and extent, and that they are also longer and less restricted on the stalk than on the club. Sometimes they are restricted on the club, but cover the whole not-scaled area of the joints of the stalk (*Leptocircus*).

c. **Setiferous Punctures.**—The antennae with restricted scaling and fine sense-hairs are, at least in Butterflies, in the places which are not occupied either by scaling or fine hairs, more or less densely covered by setiferous punctures. This sensory organ seems to be absent from, or very scarce in, the Butterflies and Moths with evenly distributed fine sense-hairs, while the puncturation is very prominent, especially at the sides of the joints, in the Butterflies with highly restricted sense-hairs and scaling (*Nymphalidae*, *Papilionidae*). The dorsal surface of the not-scaled joints has generally a mesial stripe that is bare of setiferous punctures: but there are instances in which the whole dorsal surface (except the most proximal joints) bears such puncturation all over, a kind of distribution which reminds one strongly of the distribution of fine sense-hairs over the dorsal surface of the distal joints of certain *Lycaenidae* and of the whole antennae of certain *Hepialidae* (*Hepialus*, for instance). In some *Papilionidae*, especially in *Parnassiinae*, the fine sense-hairs are often so short that they resemble the hairs of the punctures very much. As the fine sense-hairs are doubtless different in function from the

hairs of the setiferous punctures, it would be of high interest to ascertain, whether there is anything in the biology of *Papilionidae* and *Nymphalidae* which would explain the great development of the punctures in these families, especially in opposition to the *Hesperiidae* and *Lycaenidae* where the punctures are (entirely ?) absent.

d. **Configuration of the Ventral Surface.**—In connection with the restriction of the fine sense-hairs to one, two, or three patches, the configuration of the ventral surface of the joints undergoes a modification which distinguishes the antennae with restricted sense-hairs widely from those which have these sensory organs evenly distributed over the not-scaled ventral area. The ventral surface of the joints is in the Butterflies with the latter mode of distribution of the fine sense-hairs simply convex: sometimes the joints are slightly compressed, or narrowed towards the base. Here belong all *Hesperiidae* and *Lycaenidae*, as well as many *Papilionidae*. In the latter family we meet with many species that have the fine sense-hairs restricted to the proximal portion of each joint, but have preserved the simply convex ventral surface; in other *Papilionidae* the joints of the club bear a very irregular basal impression (*Parnassiinae*), which is more rounded off on the joints of the stalk, though never becoming quite regular in outline. It is especially noteworthy that the impressions are different in the various joints and also in different specimens of the same species, and that in certain species (*Parnassius apollo*) some specimens are without such impressions. Another group of *Papilionidae*, namely the species allied to *Papilio podalirius*, shows in certain species (*P. leosthenes*, for instance) two grooves close to the mesial line on the joints of the stalk, the grooves extending in a basi-apical direction, while other forms of the same group have the joints convex or slightly raised in the middle line. A constant development of two grooves is found in the Papilionids which feed on *Aristolochiaceae* and allied plants (*Papilio priamus*, *hector*, *sesostris*, etc.); the grooves are in this section of *Papilionidae* ovate, varying in depth and length in the different species, stand always rather widely apart, and never extend from the base to the apex of the joint; the mesial portion of the joints separating the grooves is simply convex, sometimes subtriangular in a transverse section. The *Nymphalidae* have also two grooves to a joint in all the species; but in this family an additional modification of the ventral surface is found in all the members (except a very few, in which the character is obliterated, as we shall see later on): that is the development of three carinae, a mesial one and two lateral ones, which occur only in *Nymphalidae*, not in any other Lepidoptera. In *Calinaga* the grooves resemble in shape and position those of *Papilio priamus* and allies (*Pharmacophagus*), but are very deep: the interspace between them is also convex as in those Papilios, but bears a distinct mesial carina (f. 47); the lateral carinae are developed only at the dorsal edges of the grooves and are not very obvious. In the *Acraeinae* the mesial, not impressed, portion of the joints is mostly also rather broad, but has a conspicuous carina, and here the lateral keels bordering the grooves dorso-laterally are well developed, extending from the base to the apex of the joint. In most other *Nymphalidae* the grooves stand very close together, being separated from each other only by the high mesial carina; the lateral carinae are generally less high than the mesial one, but are nevertheless conspicuous. The grooves on the stalk run mostly from the base to the apex of the joint, while on the club they are in many cases more shallow, especially at the apex of the joint. In the species with extended scaling the interno-ventral groove becomes on the stalk often covered with scales, while the

external groove is left uncovered; such joints (f. 55) appear to be one-grooved, but show the carinae very well, and the vestige of the second groove becomes visible on removing the scaling.

Very different from the two-grooved antennae of *Papilionidae* and *Nymphalidae* are the antennae of *Erycinidae* and *Pieridae*. In the *Erycinidae* the joints have in many species a slight mesial depression, which in other forms has developed to a rather deep groove, sometimes extending from the base to the apex of the joint (f. 11); the proximal joints of the stalk never have such grooves in this family. This simple median groove is found again in all *Pierinae*; the groove varies very much in form and size—in *Nathalis* it occupies the whole ventral surface of the joint—but is always regular in shape. The *Dismorphiinae* have three grooves instead of one, all three standing at the apex of the joint; one is mesial and larger than the others, which are lateral; in many cases the three grooves are not entirely separated from each other (figs. 29—31).

The Heterocera have very often the simply cylindrical antennal joints found in *Hesperiidae*, *Lycaenidae*, and some *Papilionidae*; but one-, two-, or three-grooved antennae like those of *Papilionidae-Nymphalidae*, and *Erycinidae-Pieridae*, do not occur. It is true that many not-pectinated antennae have the joints laterally impressed (*Aganaidae*, Nov. Zool. 1896. t. 4. f. 10), but these impressions extend ventro-dorsally and cannot be compared with those of *Papilionidae-Nymphalidae*. The grooves and carinae are a special feature found only among Butterflies.

e. **Sense-Bristles.**—It now remains to give a brief survey of the stages of development of that antennal sense-organ which I described above as sense-bristle. In opposition to the fine sense-hairs, the sense-bristles are not confined to the not-scaled area of the joints, but occur also on the scaled portion of the antenna. I have not paid special attention to the bristles that stand on the scaled dorsal side of the antennae, firstly, because their study would require denudation of the joints, and secondly, because their number and arrangement is so irregular in the species examined more closely that I did not find any facts of greater weight for classification. The bristles on the not-scaled area of the antennae are mostly easily observed, but sometimes they are so short that it requires a higher magnifying power to discern them from the fine sense-hairs. The number and especially the arrangement of the bristles offer in many instances very striking distinguishing characters. Those species of *Lycaenidae* in which the distal joints are covered with fine sense-hairs dorsally and ventrally have also the sense-bristles evenly developed on the dorsal and ventral surface, each not-scaled joint bearing a complete belt of bristles (f. 9). In all other Butterflies the dorsal and ventral side of the joints are different in the development of the bristles, but we find in some *Erycinidae* a series of bristles nearly all round the distal joints. The joints of the stalk have often the bristles less regularly arranged than the joints of the club. The not-scaled ventral surface of the club bears in all Lycaenids and Hesperids a transverse series of bristles (often reduced in number), and such a row of bristles we find also in certain *Papilionidae*, but here the series is irregular (f. 39, *Leptocircus*). The transverse, apical, series of certain *Erycinidae* is reduced in other forms of this family, sometimes so much, at least on the stalk, that only one, externo-lateral, bristle is left (f. 14); the lateral bristles are nearly always developed and stand generally near the middle of the joint, while the more mesial bristles keep their position near the apical edge. The bristles of the *Pieridae* are constantly reduced in number; most species have a lateral, median or submedian, pair, and an apical, submesial, pair (figs. 15—31).

In *Papilionidae* the number of the ventral bristles is very variable and their position very irregular; besides *Leptocircus* with an irregular transverse series on a number of joints, we find sometimes an indication of a subapical or postmedian series in some Papilios (for instance in the *female* of *P. agamemnon*, f. 36); other species have a number of lateral bristles without any regular arrangement, and the Papilios with distinct lateral grooves (*Pharmacophagus*) possess often some bristles between the grooves (f. 40). These latter bristles are perhaps homologous to a pair of bristles that appear constantly in *Nymphalidae*. The ventral bristles of *Nymphalidae* (inclusive of *Calinaga*, which was described as a Papilionid) are surprisingly regular and constant in number and position, the mode of distribution being quite unique among all Lepidoptera (figs. 47—72). There are in all forms of this vast family, if the bristles are not obliterated, two pairs of bristles, one pair at the base of the joint near the mesial carina, the other lateral at the dorsal side of the lateral carina. The second pair varies in position in the different forms of Nymphalid Butterflies in so far as it is sometimes more basal, sometimes more apical. Both pairs are in a number of cases much reduced in length, but seldom not visible (except in a transverse section of the joint).

Among Moths we meet forms which resemble certain Butterflies very much in the mode of distribution of the bristles. There is in a number of *Hepialidae* (*Hepialus humuli*, for instance) a belt of bristles all round the joints as in some *Lycaenidae* (*Thecla*, *Arhopala*). Other Hepialids, such as have the dorsal side of the antennae scaled, have a ventral transverse series of bristles, and in many other Moths with not-pectinated antennae an irregular series is found. *Cocytia* has a transverse series of bristles arranged as in certain *Hesperiidae*, while of *Castniidae* only the distal joints of the small Australian species show distinctly a transverse row of short bristles, the large American forms possessing only one or two bristles at each side standing close to the dorsal covering of scales, except the very thin apical joints which bear a greater number of irregularly arranged long bristles. In many Moths, for instance in *Aganaidae* (Nov. Zool. 1896. t. 4. f. 1, 10), with not-pectinated antennae there are two pairs of bristles on the not-scaled ventral area, one submesial and apical, the other lateral and basal, recalling to a certain degree the two pairs of bristles of *Nymphalidae* and especially of *Pieridae*.

B. A Classification of Butterflies.

We have seen on the preceding pages that the deviation in the antennae of the various forms of Butterflies concerns a number of special organs and structures. A classification of these insects based upon the development of the antennae must take into account all those parts which we have found to offer distinguishing characters. As we have further seen that some of the antennal organs and structures undergo modifications quite independently from others, it is clear that the observations at these independently mutating parts of the antennae furnish us with facts which, if corroborating each other, admit conclusions to be drawn with a high degree of correctness as to the phyletic connection between the families of Butterflies. To find out this connection, the blood-relationship, is the ultimate aim of the classifier. The descriptive part of classificatory work provides the necessary facts; the classification is a summary of the conclusions the classifier bases upon these facts. The correctness of the classification, therefore, depends firstly on the

trustworthiness and the degree of completeness of the observations, and, if this evidence can be relied upon, secondly on the interpretation of the facts.

Now, in weighing off the evidence systematists follow two very different methods. The first method, a relic from pre-Darwinian times, is by far the dominant one in ordinary systematic work, because it is so very convenient; it consists in taking as the basis of the primary division of the group (and subsequently of each subgroup and minor division) certain distinguishing characters which the respective classifier assumes to be of primary importance, without giving any reason (1) why the forms which possess that character are closer related to each other than to forms which do not possess it, and (2)—and this is the point where the grave mistake comes in—why the forms that are devoid of that character are all phylogenetically closer connected with each other than with forms which have the respective character. It is obvious that the result of this method entirely depends on what characters the classifier selects for gradually dividing up the group of forms, and, as the selection is arbitrary inasmuch as the phyletic significance of the selected character is merely assumed to be warranted, that the classification is based on a string of assumptions. Hence it is self-evident that the classifications drawn up by different authors according to this method must naturally deviate widely from one another, if the classifiers do not make the same assumptions; and as there is no reason why they should select the same distinguishing characters and use them in the same order, the antagonistic results of different authors are merely antagonistic assumptions. The contradiction between different systems of classification based on different primary assumptions is in the case of Butterflies very obvious. According to Professor Grote, the Butterflies have a diphyletic origin, the forms with a vein on the forewing running into the posterior margin of the wing (*Papilionidae*) forming the one, all the other Butterflies, which do not possess such a vein in such a position, the other phylum. However, a diphyletic origin of the Butterflies we should also have if we took a character of the claws as the basis of the primary division; but in this case the *Pieridae*, which have all divided claws, would be the one phylum, and all the other Butterflies (inclusive of *Papilionidae*) with not-divided claws belong to the other. Or, if the degree of abortion of the forelegs were made the basis of division, we should have *Hesperiidae*, *Papilionidae*, and *Pieridae* as one hexapod phylum, the *Lycaenidae* and *Erycinidae* (and a few *Nymphalidae*) as a heteropod phylum, and the *Nymphalidae* as a tetrapod phylum. Again, the *Nymphalidae* would stand separate from all the rest of the Butterflies if the presence of carinae on the antennae were considered to be of primary importance; while we should have four primary groups if we took into consideration the development of antennal grooves, the first group containing the forms without grooves (*Hesperiidae*, *Lycaenidae*, many *Papilionidae*), the second the forms with one groove (*Erycinidae* and *Pierinae*), the third consisting of the forms with two grooves (*Nymphalidae* and many *Papilionidae*), the fourth of forms with three grooves (*Dismorphiinae*). And so on. The great difference in the grouping of the Butterflies according as we take this or that organ for the basis of division most obviously shows that such classifications are merely a grouping of quantitatively the same degrees in the development of the respective organ, the grouping being carried out regardless of the individuals exhibiting the similar character having arrived at that stage of development on the same or on different roads, and taking it for granted that the difference in the character selected for division indicates different phyletic origin. Though such a classification is artificial, it is nevertheless striking that, when grouping the

Butterflies according to the various organs and structures of the antennae, we see again and again the *Hesperiidae* brought together with the *Lycaenidae*, and find the *Nymphalidae* in several instances separated from the rest of the Butterflies, the *Papilionidae* linked with the *Nymphalidae*, and the *Pieridae* with the *Erycinidae*. Such agreements leave no doubt that there is some truth in every artificial classification, even if its basis of division is "habitus": and it seems very well possible to arrive at a fairly correct grouping by comparing a number of artificial classifications, or, as it is generally styled, by basing a classification on the differences and similarities exhibited by the insects in several organs, taking those forms as more closely related which agree in the greater number of characters.

Although the grouping thus arrived at might ultimately prove to be correct, it is nevertheless artificial, since that evidence is taken as the more weighty, *i.e.* as qualitatively the better, which is merely numerically, *i.e.* quantitatively, the higher, and also unsatisfactory, as it does not account for all those many cases in which members of groups standing widely apart in the system have characters in common which other members of these groups lack. A satisfactory insight into the true connection between the members of any group of animals will not be gained, unless the classifier takes as his aim to ascertain, so far as that is possible from the necessarily incomplete knowledge of the organs, the probable phyletic development of each single distinguishing character, so that we get a picture of the gradual modification of the various organs from the ancestral stage of development into those stages of mutation which we now observe in the different members of the group to be classified.

Though at first thought this speculative method of building up a classification appears to be of a very hypothetical nature, it will be seen on closer examination that the method works with less assumptions than that described above, and that, moreover, it does not admit any such assumptions to be made without a close inquiry into their admissibility. The separation of the *Pieridae* from the other Butterflies on account of their divided claws is arbitrary, unless it can be shown that the divided claw is not a specialisation of any other Butterfly claw comparatively lately acquired, and that it was also not a character of the common ancestor of the Butterflies independently lost at different times by the various branches into which the Butterflies developed, being kept only by a portion (the *Pieridae*) of one of the branches. The presence of the Papilionid vein on the forewing of the *Papilionidae* (the vein that runs into the hinder margin) will justify attributing to the *Papilionidae* a separate origin from the other families of Butterflies, if there is no homologon of that vein in these other Butterflies (which there is), and if it is also out of the question that the vein has obliterated independently in them. The preservation of six fully developed legs, clearly an ancestral character, in *Hesperiidae*, *Papilionidae*, and *Pieridae*, is no more an argument for a closer phyletic connection between these families on the one side, and between the other Butterflies with reduced forelegs on the other, than is in Moths the reduction of the rostrum or of the wings, or the absence of a frenulum or of tibial spines, or in Butterflies and Moths the loss of scales, etc., an argument for a close relationship of the forms in which such a reduction or loss is observed.

It will be apparent from these illustrations, that there is a wide difference between the method of building up a classification on assumptions, and the speculative method in which the phylogenetic value of the differential characters has to be investigated before they can be made use of, and that only this latter

method will yield results satisfactory to the inquiring mind of the naturalist. The difficulty in the speculative method is, that one has to account for all the similarities and differences in the various organs of the groups classified, and the danger in it is, that only such characters are brought forward which suit the purpose best, while the others are left alone. In the case of a classification of the Butterflies based upon the characters of the antennae that difficulty does not seem to me to be insurmountable, and I hope to avoid that danger altogether.

The scaling is a special feature of Lepidoptera. Scales are modified hairs. Only in Lepidoptera do we find the antennae clothed with scales; in all other insects they have a covering of hairs and bristles which are mostly sensory in function. In the nearest allies of Lepidoptera, in Trichoptera, the antennae are furnished all over with a covering of sensory hairs. The scaled Lepidopterous antennae are, therefore, doubtless derived from a not-scaled hairy ancestral type.

The development of the sense-hairs of the antennae into scales may have taken place together with the appearance of scaling on other parts of the body, or the antennal scaling may have been acquired after the scaling of other organs had become a relatively constant character of Lepidoptera. If the first alternative is correct, we should expect that intermediate stages between the hairs and scales as regards form would be met with in such Lepidoptera where mutation is obviously in progress, the scaling either varying in extent individually, or being different in extent in closely allied species. However, the excess in the extent of scaling of one individual over the other, or of one species over its close ally, consists of scales like those of the rest of the scaled area; this new, or more recently acquired, scaling does not show any greater similarity to hairs than does the phyletically older scaling. On the other hand, this sharp demarcation between scaled and hairy areas of the antennae, and the abrupt appearance of fully developed scales in certain individuals, or species, in excess over the scaling of other individuals, or species, are decidedly in favour of the second alternative. For, if the sensory hairs of the Lepidopterous antenna began partly to lose their sensory character in the course of evolution after the non-sensory hairs of other organs had become modified into scales, the physiological forces which produce in each Lepidopteron, instead of hairs, the scales, would have free play also with these non-sensory hairs of the antennae; the non-development of the nerve-cell of the antennal hair in pupal life would directly lead to the development of a full-sized scale. This suggestion, that the ancestral scale-winged insects had hairy antennae, is fully borne out by what we know about the extent of the covering of fine sense-hairs in certain Lepidoptera.

We have seen above that the area covered with fine sense-hairs is in some species much smaller than in closely allied forms, part of the hairy area being in the latter species occupied by scaling. As the presence of scales brings always with it absence of sense-hairs from that place, it is obvious that the hairs have become modified into scales. The fine sense-hairs, which we have so often mentioned in the descriptions of the Butterfly antennae, represent, therefore, a type of hair from which the antennal scaling of Lepidoptera may have been derived. The most generalised type of antenna covered with hairs would be one in which the hairs were equally distributed over the whole surface, and such a type we find preserved in certain *Hepialidae* (in *Hepialus humuli*, for instance). If we consider further that this type cannot have developed from a scaled antenna, because such a derivation would necessitate the assumption that the sensory function which was lost when the hairs

became scales had been re-acquired—an assumption which I do not admit—the occurrence of antennae covered all over with sense-hairs is intelligible only if the ancestral antenna was of a similar type. Hence we have to regard the antennae differing from that ancestral type of the whole order as specialisations into which the ancestral form of antenna has developed, and now come to the question, whether the Butterfly antennae are directly derived from this most primitive type or from a later development of it, and whether the various Butterfly antennae developed independently of those of the Moths and independently of one another (in respect to scaling).

In all Butterflies and Moths, with the exception of some *Jugatae*, the dorsal and ventral sides of the antennae are different in respect to the development of sense-hairs and scaling; these antennae are, therefore, all more or less specialised. But the different degrees of specialisation met with in Butterflies show us clearly from what kind of ancestral antenna the various Butterfly antennae must have developed. The ventral side is in very many species of all Butterfly families, except *Hesperiidae*, covered all over with fine sense-hairs, and the same character obtains on the upperside of the distal joints in many *Lycaenidae*. Hence it is evident that we must attribute to the original stock of Lepidoptera, from which the Butterflies developed, antennae very similar in the development of fine sense-hairs to those of the ancestor of the whole order, but perhaps with a more or less extended dorsal scaling.

In the further development of this ancestral antenna the dorsal and ventral side did not lose the generalised character at the same time, both sides deviating markedly from each other. From the facts, firstly, that in many Butterflies and nearly all Moths the ancestral covering of fine sense-hairs is still present on the ventral side, while the dorsal side is in nearly all Lepidoptera specialised, and, secondly, that in the species in which both sides are specialised the sensory hairs are more restricted dorsally than ventrally, the ventral side never being in advance over the dorsal surface in this respect, we are justified in inferring that the modification of the sensory hairs began on the dorsal side. As further the ancestral character of a covering of fine sense-hairs is kept in many *Lycaenidae* on the dorsal surface of the distal joints, while the rest of the dorsal surface is densely scaled, and the dorsal not-scaled area is always distal in all Butterflies, if the dorsal side is not totally covered with scales, the development of the scaling must have set in at the base and proceeded in a basi-apical direction, so that the totally scaled dorsal surface is a later acquirement. The gradual modification of the sensory hairs into scales in a basi-apical direction is beautifully illustrated in *Jugatae*, where we find all intergradations between antennae with totally hairy and totally scaled dorsal side, the not-scaled portion preserving the generalised character.

The acquirement of extended dorsal scaling is not always the end of this line of development. Those many species which are closely related to species with extended antennal scaling, but have neither scales nor sensory hairs on the dorsal side of the antennae, and hence are not of a more ancestral type, clearly show that their dorsally naked antenna is a derivation from a scaled one. There are *a priori* two ways upon which the antenna can have arrived at this stage of development. The first possibility is that the fully scaled area became restricted gradually in an apici-basal direction without a reduction in the number and size of the scales of the rest of the area, retracing backwards the steps of development which originally led to an extended scaling. But the intergraduate stages between the not-scaled and

the extendedly scaled antenna are absent, the stalk, at least, being always fully scaled in the species with a densely scaled area ; and it is not admissible to explain the absence of intergradations by the assumption that the intergraduate forms are lost, but have been there in the course of the phyletic development of the Butterflies, because the species without and with extended dense dorsal scaling are often much too closely related in other respects to warrant the all-round disappearance of intergraduate forms. Moreover, the scaling is not in all species dense. The many forms in which the scaling, though found on all the joints of the stalk and on the proximal joints of the club, is sparse, or in which the scales are small (*Charaxes*, many *Neotropinae*), preserving sometimes only a few scales on each joint (*Mesapia*), and thus representing intergradations between the densely scaled and naked antenna, show that most probably the first step towards the disappearance of the dorsal scaling was that the scales became more scanty, or smaller, or both.

The highly remarkable facts (1) that we find in Heterocera (apart from *Jugatae*) the dorsal side of the antennae either bare of scales and of sensory hairs in relatively few forms (*Saturniidae*, *Ceratocampidae*, *Amerila*), or covered with scales up to the last joint, there being to my knowledge no such stages of development found in which a larger or smaller number of distal joints is dorsally naked, as is so often the case in Butterflies : (2) that **all** the *Hesperiidae* agree with the bulk of the Moths in having the dorsal surface entirely covered with scales, and have, besides, in **all** the members of the family at least the stalk covered with scales also ventrally; (3) that the *Dismorphiinae*, which are also highly specialised in the development of the scaling, show a high degree of specialisation in other antennal organs in **every** species : and (4) that in **all** the forms of *Danainae* the dorsal surface is naked (except the basal joints) in consequence of obliteration of the scaling,—all point in the one direction, namely that, when a high degree of specialisation is reached, the forms are relatively very constant in respect to that character. Hence it does not seem to me to be rash to conclude, that also in the families where only a certain number of species is highly specialised in the antennal scaling, this specialised character is not easily, if at all, liable to further mutation, and that consequently the species in which the distal joints are bare of scales and sensory hairs are probably not derived from forms which were so highly specialised as to have the entire dorsal surface of the antennae scaled, but from less specialised forms in which the distal joints had a covering of sensory hairs, which obliterated.

The principal conclusions relating to the development of the dorsal scaling are these : the ancestor of Butterflies had a dorsal covering of fine sense-hairs which became modified into scales in a basi-apical direction ; antennae with more extended dense scaling are derived from antennae with less extended scaling ; antennae with the distal joints bare of scales are derived from such in which these joints were covered with sensory hairs ; antennae with sparse scaling (in a state of obliteration) are derived from antennae with dense scaling, the process of obliteration resulting in naked antennae ; naked antennae can also be derived directly from antennae with dorsal covering of sense-hairs.

Now, the ventral side of the antennae having in many species of all families of Butterflies except *Hesperiidae* a covering of sensory hairs all over, must have been without scaling in the ancestral forms of these families. The scaling appears first on the proximal joints, where it is found in many species which have the rest of the under surface provided with hairs, and the development proceeds in a basi-apical direction as on the upperside. The end of this line of development is, however, not

a totally scaled underside: that never occurs; there is always a distal area beset with sensory hairs left not-scaled. Nor have I found the ventral scaling in any species in a state of obliteration, a process which would lead to the scaled portion of the ventral surface becoming naked, as we have seen on the upperside; but the sensory hairs are very often fewer in number at the apices of the joints and at the sides. Hence the extended ventral scaling means always higher specialisation than the less extended scaling.

The restriction of the not-scaled ventral area to the distal joints of the antenna is not a feature common to all Lepidoptera that have extended ventral scaling; for we have seen that in the Moths with extremely long and thin antennae (*Chimabache*, for instance) the apical portion is all scaled. But in Lepidoptera with clubbed antennae the sense-hair-bearing area, if restricted, is always apical, and this is not only the case in Butterflies, but also in those Moths in which the clubbed antenna has an extended development of ventral scaling (among *Castniidae*, *Sesiidae*). The restriction of the sense-hair-bearing area to the apex of the antenna is, therefore, dependent on the development of a club, and hence must be a character acquired subsequently to the modification of the originally filiform into clubbed antennae. If this is so, then we can satisfactorily explain why members of different families agree in the extent of the antennal scaling. The cause of the similarity in specialisation is not direct relationship, but development in a definite direction which is the same in the not nearly related Butterflies because the antennae are all clubbed. That the restricted sense-hair-bearing area is always ventral, not dorsal, is also very intelligible, as the current of the air, which is to be analysed by the sensory hairs, strikes the ventral surface of the antenna of the flying insect. The facts that in the Moths with very long antennae the not-scaled area is restricted to the basal half, and in the clubbed antennae of Butterflies and certain Moths to the distal joints, do not contradict each other, as it is in both cases the portion that protrudes mostly frontad, and hence receives the current of the air first, which bears the sensory organs, the long antennae floating backwards during flight.

If we now apply these conclusions to the various families of Butterflies with a view of finding the phyletic connections between these insects, we shall arrive at some interesting results.

The *Hesperiidae* are, on account of the not-scaled area being restricted to the club in all species, the most highly specialised family (as to antennal scaling). As not a single species has the not-scaled area extending down the stalk, all the members of the family can be derived from an ancestral Hesperid in which the whole antenna except the ventral surface of the club was scaled. But considering that the scaling both of upper and under surface develops in a definite, basi-apical, direction, which must necessarily lead to the same result, as said above, it is also possible that the various groups of *Hesperiidae* diverged from one another in other characters before that large amount of scaling had been acquired. So much, however, is certain that the *Hesperiidae* originated from a form in which the development of dorsal and ventral scaling was in progress, else it would not be intelligible why all the species are so remarkably specialised in the same way in this respect: and as the proximal ventral scaling is a later development than the club, the *Hesperiidae* must have sprung from Lepidoptera with clubbed antennae of which the dorsal and ventral surfaces were scaled to a probably considerable extent, the rest of the organ being covered with sense-hairs.

The ancestors of *Lycaenidae*, *Erycinidae*, and *Pieridae* must have had the

ventral surface and, besides, the dorsal surface of at least the apical half of the club covered with sense-hairs. As there is in all three families not one species which is without dorsal scaling on all the joints of the stalk and proximal joints of the club —in *Mesapia*, a Pierid, with sparse scaling, more recent obliteration of the scales has taken place—it is obvious that the ancestral form of each of the three families most probably was already in an advanced stage of development of the dorsal scaling. *Nymphalidae* and *Papilionidae*, though very often without antennal scaling in consequence of obliteration of the scaling, are to be derived from a form with the entire ventral surface and the dorsal side of at least the club not-scaled.

From this review the one point is most obviously clear, that the *Hesperiidae* cannot have been the basis from which any of the other Buttertly families developed.

The modification of the fine sense-hairs into scales is, as we have seen, accompanied in many instances by a modification of a portion of the remaining hairs into another kind of sense-organ, the setiferous punctures. We have, therefore, to distinguish between Lepidoptera which have preserved the ancestral character, a covering of fine sense-hairs, on the not-scaled area of the antenna, and such in which that specialisation obtains. The generalised character is met with on the dorsal side only among *Lycaenidae*, in no other Lepidopterous family apart from *Jugatae*, a fact of high significance ; while the ventral not-scaled area of the antennae is of the same generalised character not only in all *Lycaenidae*, but also in all *Hesperiidae*, in the *females* of certain *Papilionidae*, and in the Heterocera ; but among the last the sense-hairs show often specialisation in so far as they are often longer at certain points than at others, especially in the *males*.

The modification which the underside has undergone is of particular interest, as the preservation of different steps of the progressing specialisations reveals to us divergent lines of development of the Butterfly antennae. When speaking here and in the following pages of the underside of the antenna, I mean that portion of the under surface that is not covered with scaling ; it is the interno-ventral side.

The setiferous punctures appear first on the distal joints, as may be seen in *Erycinidae* and *Papilionidae*, and the specialisation proceeds in an apici-basal direction. The fine sense-hairs are not entirely replaced by setiferous punctures on any joint, there remaining part of the surface of the joint covered with hairs. The apices of the joints or the sides are the first to acquire the punctures, and this corresponds exactly with what we know of the development of the ventral scaling, which begins in very many instances also at the apex and sides of the joint, leaving a mesial or a basi-mesial space free (figs. 6, 38). The fine sense-hairs are, therefore, first restricted to the basal and mesial portion of the joint. Now, we have seen that in the greater proportion of Buttertlies with restricted sense-hairs the portion of the underside that bears the patch (or patches) of fine sense-hairs is more or less impressed ; hence it is obvious that the appearance of one, two, or three grooves stands in close connection with the restriction of sense-hairs. As in *Papilionidae*, for instance in *Papilio machaon* and allies, the division of the basal area of sense-hairs of the distal joints sets in without the previous development of grooves, it is evident that the grooves represent a character which developed phyletically subsequently to the restriction of the fine sense-hairs. If the restriction of these sensory organs, however, preceded the development of the grooves, then it is conceivable that the further restriction of the sense-hairs has not in every case been followed immediately by a corresponding diminution in the size of the grooves,

which explains the stage of mutation found in many *Nymphalidae* (for instance in *Danainae*) which have small patches of sense-hairs and large grooves (f. 71); while, on the other hand, the close connection between the development of the patches of sense-hairs and the grooves is an explanation of the small size of both patches of sense-hairs and grooves in many other Butterflies (figs. 15, 30, 58). Among allied forms the antennae with restricted sense-hairs are more specialised than those which have the patches of sense-hairs extended, and the former again are less specialised than the antennae in which the patches of sense-hairs and the grooves correspond in shape and size. The highest degree in this direction of development would be total modification of the sense-hairs and subsequent disappearance of the grooves, a stage of development nearly reached in some *Nymphalidae* (*Satyrinae*, f. 59).

The families in which we observe the beginning of the modification of the fine sense-hairs (ventrally) and the development of grooves, namely in *Erycinidae* and *Papilionidae*, show already divergency in the first steps towards specialisation, as we learn from a comparison of the Lycaenid with the Erycinid antennae, or of the generalised antennae of certain *females* of Papilios with the antennae of the respective *males*, or of the more generalised proximal with the specialised distal joints of a Papilionid or Erycinid antenna. In *Erycinidae* the appearance of setiferous punctures begins laterally, leaving a mesial space entirely covered with fine sense-hairs, while in *Papilionidae* the modification goes on apically, restricting the fine sense-hairs to a basal patch of variable size that extends laterad. A next step in the development of the hairy areas in *Papilionidae* is that the area becomes sinuate distally in the mesial line (f. 42), and subsequently, the modification proceeding basad, divided into two patches, the development resulting finally in two well-defined, relatively small, sublateral (in *Papilio priamus* and allies) or submesial (*P. leosthenes*) patches. On the other hand, the incipient specialisation observed in certain *Erycinidae* is carried to a higher degree in other forms of this family (*Nemeobius*, f. 11), and to a still higher degree in *Pierinae*, the antennae of all these Butterflies having the sense-hairs, at least on the distal portion, restricted to one mesial patch.

However, among *Papilionidae* there is another kind of specialisation observable. In certain species of *Parnassiinae* the sense-hairs are similarly restricted basad as in *Papilio machaon* and allies, without the development of impressions, while in other species a very irregular impression appears, that in others again, at least on the stalk, becomes more rounded and more regular in shape (figs. 32—34), and we note that the more regular grooves occur in the *male* sex. If we now remember that in certain species of *Papilioninae* (*P. priamus*, *P. ambrax*, *polytes*, *memnon*, etc.), the *males* are in advance of their *females* in the specialisation of the sense-hairs respecting setiferous punctures, it is evident that here again the *male* antenna with the more regular grooves is higher in specialisation than the antenna of the *female* with irregular and more shallow grooves. That means that the not-grooved Parnassiine antenna is closer related to the little specialised Papilionine antenna as found in *P. podalirius*, *machaon*, etc., than is the grooved Parnassiine antenna. The *Papilionidae* represent, therefore, two lines of development leading from the most generalised form, as found in the *females* of *Papilio polytes*, etc. (f. 41), to one extreme with two grooves in *P. priamus* and allies (f. 40), and the other extreme with one groove in *Parnassiinae* (f. 34). As the *Nymphalidae* have always two-grooved and the *Pierinae* always one-grooved antennae, it would seem very natural to conclude

that the *Papilionidae*, consisting of forms with one, two, or no grooves, had been the basis from which the *Nymphalidae* as well as the *Pieridae-Erycinidae* developed, the former appearing as a further specialisation of the two-grooved branch of Papilios, and the latter as a derivation from the *Parnassiinae* with one-grooved antennae. Does a closer examination of the facts warrant such conclusions ?

Before entering upon the discussion of these points, it is perhaps necessary to mention that the two-grooved antenna cannot be derived from the one- or from the three-grooved antenna, and that the inverse is also not possible. For in both cases we should have to assume that the ventral surface, which in the two-grooved antenna is highest where it is most deeply impressed in the one- and three-grooved Erycinid-Pierid antenna, had developed in exactly the opposite direction to its former line of development—an assumption which is not admissible, (1) because all the forms which stand at the top of the one line of development are so much specialised in many respects that they cannot have been the basis from which the forms descended that show opposite direction of development, and are in many other characters less specialised than the former, and (2) because there are no intergradations between the pair- and odd-grooved antennae, the assumption being, therefore, entirely unsupported by facts.

Let us now examine first the two-grooved antennae. The group of *Papilionidae* in which the fine sense-hairs are most restricted, and in which the restriction is most constant in all the species belonging to the group and hence represents a high development of the grooves, must have arrived at this stage by a laterad restriction of the fine sense-hairs, since in the more generalised *Papilionidae* there is a covering of fine sense-hairs in and near the mesial line. In *Nymphalidae* the small patches of sense-hairs as found in *Danainae*, in certain *Satyrinae*, etc., within the larger grooves, as well as the small grooves of *Iphthima asterope* (f. 58), and the larger, but nevertheless much restricted, grooves of *Calinaga* (f. 47), stand apart from each other, while in the more generalised Nymphalids with extended covering of sense-hairs the two patches fill up nearly the whole grooves, being separated from each other by the not-hairy mesial carina ; the restriction is, therefore, also laterad, and, of course, basad as well as apicad, resulting always in a sublateral **rounded** patch. However, if in both families specialisation proceeds in the same direction, the results **must** be essentially similar. The agreement in the diminution and position of the patches of sense-hairs as well as in the shape of the grooves in members of different subfamilies of *Nymphalidae*, and the resemblance (not identity) of the antennae of certain *Acraeinae* (f. 52) with those of *Calinaga* (f. 47), and of the antennae of this genus with the antennae of certain *Papilionidae* (*P. priamus* and allies, f. 40), are, therefore, not necessarily arguments for these forms being phyletically closer related to each other than to forms which have not reached that degree of specialisation, the resemblance being explained by the agreement in the direction of development. The fact that the same direction of development obtains in both the *Nymphalidae* and *Papilionidae* is, however, weighty evidence for the close phyletic connection between the two families. The less specialised antennae of certain *Nymphalidae*, with extended grooves and large patches of sense-hairs, show further that the antenna of the Nymphalids cannot be a direct development from the higher specialised Papilio antenna, nor is it possible to derive the antenna of the Papilionids, on account of the very generalised forms of antennae that occur in this family, from the *Nymphalidae*, all the species of this latter family being specialised; and as we have to infer from the presence of such

a specialisation as the two grooves in all the species of *Nymphalidae* that the development of this character must have been at least incipient in the ancestor of the family, the point of divarication of the *Papilionidae* and *Nymphalidae* was probably an antenna with the extended area of sense-hairs partly divided in the mesial line. The occurrence of that typically Nymphalid specialisation, the carinae, found nowhere else among Lepidoptera, in all the species—the few apparent exceptions being explained by higher specialisation that has led to simplification—makes it further highly probable, that this entirely new specialisation furnished that character by which the early *Nymphalidae* were distinguished from the otherwise closely allied ancestors of *Papilionidae*, *i.e.* that the division of the area of fine sense-hairs into two patches in the Nymphalid branch of the Papilioni-Nymphalid phylum was accompanied by the development of grooves separated from each other by a mesial carina, and each bordered laterally by a ventro-lateral carina. As we learn from the most highly specialised Nymphalid antennae, for instance from the series of *Satyrinae* (figs. 57—59) *Ipthima asterope*, *Synchula*, and *Triphysa*, that the carinae obliterate before the grooves have disappeared, we must conclude that the carinae have always been in advance of the grooves, *i.e.* that the carinae appeared in the ancestors of the *Nymphalidae* before the grooves were developed.

It is of interest to note that in the simplified Satyrine antennae, alluded to before, the not-scaled area is very much restricted, in *Triphysa* to four joints. A comparison of *Ipthima asterope* (f. 58) with the other species of this genus, which have more generalised Nymphalid antennae with large grooves mostly extending from the base to the apex of the joints and provided with strong carinae, most obviously shows, that we have here to do with a highly specialised antenna, specialised in the development of the grooves, carinae, and scaling.

If we thus account for the similarity in the structure of the two-grooved antennae of the *Nymphalidae* and certain *Papilionidae* by deriving both families from a common ancestral stock the antennae of which had a tendency to bilateral separation of the area of fine sense-hairs and corresponding development of grooves, it is clear that the presence of one series of grooves among *Parnassiinae* would either mean that these Butterflies do not belong to the *Papilionidae*, or that the tendency of restricting the fine sense hairs laterad, not mesiad, was not common to all *Papilionidae*, and hence could also not have been present in the ancestral *Papilioni-Nymphalidae*; or, in other words, that the deduced closer relationship between the *Papilionidae* and *Nymphalidae* would not be established, **if the series of grooves of** *Parnassiinae* **is homologous to the mesial row of grooves of the odd-grooved antennae of** *Erycinidae* **and** *Pieridae*. Let us then consider the Parnassiine antennae more closely. The development of the grooves can be studied at the individuals of the same species, as the grooves are very variable in the individual specimens. We meet sometimes on the club with grooves which are laterally more extended apicad than mesially, and suggest a bilateral development, while in other individuals they are indifferently shaped. A comparison of such an irregular groove on the club with the more regular grooves on the stalk brings a remarkable fact to light: the grooves on the proximal joints of the club become more and more concentrated the nearer we come to the stalk, but this concentration does not take place equally from either side of the joint, as it must if the result should be a mesial groove, but proceeds from the inner to the outer side, thus resulting in a sublateral, not mesial, single groove. This groove is, therefore, **not** homologous to the mesial groove of *Pieridae* and *Erycinidae*, but to the externo-lateral groove

of *Papilionidae* and *Nymphalidae*. That this is so, is not so very singular as it would at first appear. The bilateral development in the antennae of insects is very often disturbed in so far as the inner side is less developed than the outer side; for instance, we see that in Heterocera with pectinated antennae the inner branches are often shorter than the outer ones, and sometimes entirely obliterated, in which case the antennae appear unipectinate. But we need not go to the Heterocera to find an analogous case of development; the *Nymphalidae* themselves show a similar development in many forms. In a number of species of this family, especially often among *Satyrinae*, as well as in *Libytheinae*, the inner grooves (figs. 51, 56) are smaller than the outer ones: in the species with a large development of ventral scaling the inner grooves become narrower and narrower the farther down the stalk we go, until they disappear entirely (f. 56). This development leads, therefore, in consequence of the disappearance of the inner grooves, also to one-grooved joints superficially similar to those of *Pierinae*. It is certainly very remarkable, that we have both in *Papilionidae* and *Nymphalidae* such asymmetrical development of the ventral surface of the joints.

As we have thus shown that the aberrant Parnassiine antenna belongs, like the aberrant antennae of some *Satyrinae* (f. 56), to the pair-grooved type, the above objection to a closer phyletic connection between *Papilionidae* and *Nymphalidae* becomes invalid, and it must be accepted as established that the present state of development of the fine sense-hairs and grooves points in every respect to the Papilionids and Nymphalids belonging together to a phylum of Butterflies with pair-grooved antennae.

The second form of antennae, the odd-grooved type, is found only in *Erycinidae* (figs. 10—14) and *Pieridae* (figs. 15—31), the former and the *Pierinae* possessing one mesial impression (often shallow) or groove on a joint, while the *Dismorphiinae* have three apical grooves, one being mesial and two lateral. The not-grooved antenna of *Lycaenidae* (figs. 6—9), which has the sense-hairs uniformly distributed over the not-scaled area, is, for this character, certainly of a more generalised form than the grooved Erycinid antenna, and the latter, which has the sense-hairs not confined to the grooves, which are moreover often scarcely indicated, is again less specialised than the antenna of *Pierinae* with the fine sense-hairs restricted to the grooves. As the gradations from the simply convex joint of the Lycaenid antenna, often scarcely distinguishable from a joint of a Hesperid antenna, to the deeply grooved joint of *Erycinidae* and of *Pierinae*, is complete, there is no doubt that the odd-grooved antenna developed from a not-grooved one similar to that of *Lycaenidae*, and further that the Pierine antenna is derived from a less specialised odd-grooved form of the type found among *Erycinidae*. Though in *Erycinidae* the fine hairs are generally not restricted to the grooves, as they are in *Pierinae*, it is in some cases, where the scaling reaches close to the edge of the grooves, difficult to say whether the joint is of a Pierid or an Erycinid type. There is, moreover, no conspicuous line of demarcation between joints without restriction of sense-hairs (*Lycaenidae*), joints with slight concentration of the hairs (*Erycinidae*), and joints with obvious restriction of the sense-hairs to the grooves (*Pierinae*). While, however, in *Erycinidae* the proximal joints are always without grooves, being of a generalised character, these joints, if ventrally not scaled, are provided with more or less obvious grooves in *Pierinae*.

The close agreement between the one-grooved antennae of *Pierinae* and *Erycinidae*, and between the Erycinid antennae with rudimentary grooves and the

not-grooved Lycaenid antennae, leaves no doubt, that the three-grooved antennae of *Dismorphiinae* represents a further specialisation of the one-grooved type, not a generalisation. There are no intergradations between the Pierine and Dismorphiine antennae known to me: the two groups of Butterflies stand in this respect more widely apart than the *Pierinae* and *Erycinidae*, and one might, therefore, be justified in giving the *Dismorphiinae* family rank. But as there is an obvious gradation among the *Dismorphiinae* from a type with three separate grooves (f. 30) to a type with the grooves joined to each other at the apical edge of the joint (f. 31), the earlier form of the three-grooved antennae had probably one transverse apical groove, widened in the middle, the mesial groove of *Erycinidae-Pierinae* pushed distad. The apical position of the grooves stands perhaps in connection with the great development of ventral scaling, as both *Dismorphiinae* and the *Nymphalidae* which have the grooves in a subapical position on each joint (*Ipthima asterope*, f. 58) possess extended ventral scaling. The absence of an indication of transition from the Pierine to the Dismorphiine antenna among *Pierinae*, as well as the great constancy in the appearance of three grooves in *Dismorphiinae*, all the species of which subfamily have this specialised character, show that the *Dismorphiinae* are not a further specialisation of any branch of the recent *Pierinae*, but must have diverged at an early time.

The relationship of the Pierid with the Erycinid antenna is here demonstrated quite independently of the above conclusion that the *Papilionidae* and *Nymphalidae* are one phylum. It is of the greatest importance to note that we bring the above two families in a second phylum of Butterflies with odd-grooved antennae, not because they do not belong to the *Papilioni-Nymphalidae*, but because their antennae show a specialisation peculiar to them, and that we consider the *Lycaenidae* to belong to the same phylum on account of the close agreement of the Lycaenid antenna with that Erycinid type in which the development of the grooves is incipient. The independence of the arguments for a connection between *Nymphalidae* and *Papilionidae* on the one side, of those which speak for a relationship between *Lycaenidae*, *Erycinidae*, and *Pieridae* on the other side, lends additional strength to them.

Of quite a different type from the fine sense-hairs and setiferous punctures are the "sense-bristles" found on both the scaled and not-scaled areas of the antennae. Their development is independent of that of those other sensory hairs, and hence the evidence they offer in respect to the relationship of the families of Butterflies is of great weight. As the number of bristles is always very limited in Lepidoptera, the bristles never forming a covering of the joint, as the fine sense-hairs do, the most generalised antenna, in which all the sides are similarly developed, should have the bristles arranged in belts running round the joints. And, indeed, we find such an arrangement among *Jugatae*, the belt being, however, often disturbed. Can a regular belt be the character that obtained in the ancestor of Lepidoptera? That the bristles of Moths and Butterflies can be derived from a single row is certainly an argument not speaking against the Hepialid arrangement representing that of the ancestral type; but much more convincing than this argument are the facts that we find a nearly regular postmedian belt of bristles among *Lycaenidae*, that many other Butterflies have on the not-scaled ventral surface of the club the bristles also arranged in one transverse series, and that among Heterocera the ventral surface has a similar row of bristles, for instance in *Coeytia*, while in many other

Heterocera with cylindrical (little specialised!) joints we meet with an irregular transverse row. Moreover, it is often very obvious from the position of the bristles in the Lepidoptera which do not possess a transverse series that these irregularly placed bristles are derived from a more regular transverse series, inasmuch as we find very generally, especially on the club, that the one bristle stands upon the interspace of two others. It is highly interesting to observe that the generalised Hepialid arrangement of bristles obtains, of all Lepidoptera, again in the *Lycaenidae*: it is certainly not a mere coincidence that just those Lepidoptera which we had to consider the most generalised in respect to the fine sense-hairs show that belt of bristles all round the joint, while all other Lepidoptera have the dorsal (scaled or not-scaled) and ventral sides differing considerably in the arrangement of these organs.

The modifications which the regular postmedian belt of bristles, as found among *Lycaenidae* (f. 9), undergoes are of two principal kinds: a reduction in the number of the bristles and an alteration in their position. Both kinds of development may occur at the same time on the same antenna.

There are many antennae which have the bristles in a generalised state ventrally and specialised dorsally, while the inverse never occurs; hence it is clear that the specialisation begins dorsally, and that, therefore, the next generalised stage after the Lycaenid-Hepialid antenna is represented by a form in which the ventral surface has the belt of bristles intact, while the bristles are irregular in position and reduced in number dorsally. Such a stage of development we meet with largely among *Lycaenidae* and *Hesperiidae* (figs. 1, 8). From this second type a third one, found among *Lycaenidae*, *Hesperiidae*, and largely among *Erycinidae*, resulted by an apical or basal movement of the series of bristles. The apical movement is comparatively rare in *Lycaenidae* (f. 7) and *Hesperiidae* (f. 2), and seems to occur here only in forms which have the bases of the joints depressed, while in *Erycinidae* it is the rule, at least as regards the club (f. 13). From the fact that certain bristles, for instance the lateral bristles of *Nymphalidae* (figs. 47—72), have a different position in allied forms, while other bristles remain the same in position, we must conclude that the bristles can change their place independently of each other. This changing of position always takes place in a longitudinal direction; a widening and stretching, or a reduction in the length and width of a joint, or a portion of a joint, affects naturally the mutual position of the bristles, but if in allied Lepidoptera the joints are of the same form the bristles move apical or ventrad, when a change in position occurs. This independent movement of the bristles leads, however, necessarily from a more regular belt to an irregular series, as we find it, for instance, in some *Papilionidae* (f. 39, *Leptocircus*). In by far the greater number of Lepidoptera a reduction in the number of the bristles obtains, and we observe that throughout the whole order it is the most lateral bristle at each side of the ventral surface which is preserved longest (f. 5), and that, if reduction goes on, the interno-lateral one is the first of the two to disappear (f. 14). The highest degree of reduction is, of course, reached when all the bristles have obliterated, a stage found largely among *Parnassiinae*. The reduction of the ventral bristles stands in this subfamily perhaps in correlation with the stronger development of the dorsal bristles (f. 35). Besides the lateral pair nearly constantly met with in Butterflies and Moths with a reduced series, we find also very often a submesial pair preserved. Both the lateral and the submesial pair are often different in position in different groups (*Nymphalidae*, figs. 47—73; *Pieridae*, figs. 15—31); whereas in the same group their position is often constant, sometimes very constant (compare submesial basal pair in

figs. 47—72), and this constancy indicates that the character was at least incipient in the ancestral antenna of the respective group.

As we have thus seen that the antennae with a reduced number of bristles represent a more specialised state than those with a less, or not, reduced series, and that the forms with the series irregular are less generalised than those which have a regular belt, the development of the bristles admits the following conclusions to be drawn as to the phylogeny of the families of Butterflies :—

The preservation of the most ancestral form of arrangement of the bristles in *Lycaenidae* makes it evident that the Butterflies taken as a whole are not a further development of any recent family of Moths (apart from *Jugatae*), and that they are closer connected in the characters of the bristles with the ancestral Lepidopteron than any Frenate Moths are. The *Lycaenidae* being the only family in which the ancestral character is preserved, all the other Butterflies being more or less specialised, it is further clear that the *Lycaenidae* are not a derivation from any other recent Butterfly family.

The *Hesperiidae*, having in many instances an ancestral, ventral, belt of bristles, can but be derived from a Lepidopteron with a regular postmedian series, and they may, therefore, have developed from the *Lycaenidae*. But the agreement of the two families in the preservation of the ventral generalised series of bristles is not a conclusive argument for their being very close allies ; for the *Hesperiidae* may just as well have originated direct from the ancestral Butterfly, or even from the ancestor of all Lepidoptera. The apical, specialised, position of the row of bristles in a few *Hesperiidae* and *Lycaenidae* (figs. 2, 7) would at first thought seem to suggest, that we had here to do with a specialisation which was an expression of relationship of the two families ; but the antennae in which that specialisation occurs are such as have the base of the joints depressed, and hence it is possible that the apical position of the bristles is merely a consequence of this configuration of the surface of the joints.

The nearly complete belt of bristles on the apical joints in some *Erycinidae*, and the constant position of the mesial and submesial bristles near the apex of the joints on the club, show that this family is a derivation from a form which agreed with the early *Lycaenidae* in the possession of a belt of bristles, and deviated from the ancestral stock by the apicad movement of the mesial bristles. The more highly specialised *Erycinidae* agree closely with the *Pieridae* in the possession of one or more lateral bristles and an apical submesial pair ; and as this character is constantly found on the club in those *Pieridae* in which the submesial bristles are not obliterated, and in no other specialised family, we must conclude that there is a closer phyletic connection between the *Pieridae* and *Erycinidae* than between the *Pieridae* and any other family. The *Pieridae* certainly cannot be a derivation from the *Parnassiinae*, on account of the absence or very different position of the always much reduced bristles of *Parnassiinae*; while, on the other hand, the *Pieridae* also cannot have given origin to any other recent Butterfly family, as the Pierid specialisation is very different from the Nymphalid specialisation, and as in the other families we find antennae of a much more ancestral type.

In *Papilionidae* we meet again with a subancestral development of the bristles in some members (f. 39, *Leptocircus*) : the family cannot, therefore, be a development from the always specialised *Nymphalidae* or *Pieridae*, but can be derived, as far as the bristles are concerned, from the *Lycaenidae* or *Hesperiidae*, or may have originated direct from the ancestral stock common to all Butterflies ; all three

assumptions explain equally well the occurrence of an irregular but complete ventral belt of bristles among *Papilionidae*, and hence are equally admissible. The further development of the bristles leads in *Papilionidae* largely to obliteration: but we observe in forms with two ventral grooves (f. 40) a basad movement of the mesial bristles. Such a basad movement of a submesial pair must have taken place very early in the ancestral *Nymphalidae*, since this pair of bristles has in all members of the very large family a basal position. On account of the great and constant specialisation of the bristles the *Nymphalidae* are not the basis from which any other family developed: but the similarity in the direction of the development of the mesial bristles between *Nymphalidae* and some of those *Papilionidae* which have, like the Nymphalids, pair-grooved antennae, is additional evidence of relationship of the two families.

To sum up we will briefly recapitulate our interpretation of the state of development of the four parts of the antennae which we have especially been dealing with, and state the principal conclusions arrived at as to the phyletic connection of the various Butterfly families:—

I. *Hesperiidae.*

1. Dorsal and ventral scaling specialised; similar specialisation occurring in members of all other families except *Papilionidae*. *Hesperiidae* cannot be the basis from which any other family developed.
2. Ventral fine sense-hairs generalised. *Hesperiidae* cannot be derived from any other family but *Lycaenidae*, or the ancestor of *Lycaenidae*.
3. Configuration of ventral surface ancestral. Conclusion as to phylogeny as before.
4. Sense-bristles ancestral, or specialised; specialisation as in certain *Lycaenidae*, or peculiar to *Hesperiidae*. Probably connection between *Lycaenidae* and *Hesperiidae*.

II. *Lycaenidae.*

1. Scaling subancestral, or specialised as in other families. Dorsal side never without scaling. Indifferent.
2. Fine sense-hairs distally of lowest type among all Lepidoptera, apart from some *Jugatae*, or at least ventrally ancestral. *Lycaenidae* cannot be derived from any other family of Butterflies.
3. Configuration of ventral surface ancestral, but sometimes faint indication of Erycinid specialisation.
4. Sense-bristles ancestral on distal joints dorsally and ventrally; lowest type among Lepidoptera except certain *Jugatae*: sometimes specialised as in *Erycinidae*, seldom as in *Hesperiidae*. *Lycaenidae* cannot be derived from any other Butterfly family, but stand in relationship with *Erycinidae* and probably also *Hesperiidae*.

III. *Erycinidae.*

1. Scaling subancestral, or specialised as in other families. Dorsal side never without scaling.
2. Fine sense-hairs ventrally subancestral or distally specialised nearly as in *Pierinae*. *Erycinidae* closely connected with *Pieridae*.
3. Configuration of the ventral surface subancestral, or specialised as in *Pierinae*: one-grooved antennae. Conclusion as before.

4. Sense-bristles subancestral, or specialised as in *Pierinae* or as in certain *Lycaenidae*. Connection with *Pieridae* and *Lycaenidae*; no connection with *Papilionidae* and *Nymphalidae*.

IV. *Pieridae*.

1. Scaling subancestral, or specialised as in other families. Dorsal side never entirely without scaling.
2. Fine-sense hairs specialised as in *Erycinidae*, but more highly so. *Pieridae* cannot be the stock from which any other family branched off.
3. Configuration of ventral surface specialised, of the Erycinid type (*Pierinae*), or of a type found nowhere else (*Dismorphiinae*): one-grooved and three-grooved antennae. No other family can be derived from the *Pieridae*.
4. Sense-bristles specialised as in certain Erycinids, sometimes obliterated. No connection with *Nymphalidae* and *Papilionidae*.

V. *Papilionidae*.

1. Scaling subancestral, or specialised as in other families, or reduced as only among *Nymphalidae*. Connection between *Papilionidae* and *Nymphalidae*.
2. Fine-sense hairs ventrally generalised, or specialised of a type peculiar to the family, or specialised as in *Nymphalidae*. Development of setiferous punctures on dorsal and ventral surface as in *Nymphalidae*. *Papilionidae* cannot be a derivation from *Nymphalidae*, *Pieridae*, or *Erycinidae*. Close connection between *Papilionidae* and *Nymphalidae*.
3. Configuration of the ventral surface ancestral, or specialised, of a type peculiar to the family or similar to that of *Nymphalidae*. Conclusions as before.
4. Sense-bristles subancestral, or specialised; specialisation sometimes in the same direction as in *Nymphalidae*. Conclusions as before.

VI. *Nymphalidae*.

1. Scaling subancestral, or specialised as in other families; loss of scales as only in *Papilionidae*. Connection between *Nymphalidae* and *Papilionidae*.
2. Fine sense-hairs specialised as in certain *Papilionidae*, sometimes nearly all obliterated; on dorsal and ventral surface appearance of setiferous punctures as among *Papilionidae*. Close connection between *Nymphalidae* and *Papilionidae*; *Nymphalidae* cannot have given origin to any other family.
3. Configuration of ventral surface of peculiar type, but resembling that of certain *Papilionidae*: two-grooved antennae; carinae found nowhere else in Butterflies. Conclusions as before.
4. Sense-bristles specialised, of a peculiar constant type, recalling that of certain *Papilionidae*. Conclusions as before.

It will be seen from this summary that the Lycaenid antenna is the most generalised and the Nymphalid antenna the most specialised of all Butterfly antennae, and it will further be noticed that certain specialisations are common to

the *Lycaenidae*, *Erycinidae*, and *Pieridae* on the one hand, while other specialisations are found in *Papilionidae* and *Nymphalidae*. Not a single specialisation connects *Lycaenidae*, or *Erycinidae*, or *Pieridae* closer with *Papilionidae*, or with *Nymphalidae*. The specialisation in scaling points to a connection between *Nymphalidae* and *Papilionidae*: the fine sense-hairs speak for close relationship between *Lycaenidae-Erycinidae-Pieridae*, and between *Papilionidae-Nymphalidae*; the configuration of the ventral surface points very obviously in the same direction; and the sense-bristles speak again for the same connection. As, therefore, all the characters which are not indifferent are for a phyletic connection between *Lycaenidae-Erycinidae-Pieridae* on the one side, and between *Papilionidae-Nymphalidae* on the other, it is obvious from those statements that, leaving out of consideration for the present the antenna of *Hesperiidae*, the Butterfly antenna developed early in two directions, the development resulting on the one hand in the odd-grooved Lycaenid-Erycinid-Pierid antenna, and on the other in the even-grooved Papilionid-Nymphalid antenna.* Now, as not one of the four antennal organs dealt with is specialised in all the members of the Lycaenid-Erycinid-Pierid branch of Butterflies, every one being at least in some members of an ancestral type, it is evident from the absence of a distinguishing character between the whole branch and the ancestral Butterfly that this branch of Butterflies cannot have diverged from the original stock before the Papilionid-Nymphalid branch had become specialised. The divergent development of the two phylums began with a specialisation of the ancestral *Papilioni-Nymphalidae*: and as this specialisation must have taken place in those antennal organs which show the same or similar direction of specialisation in all members of the phylum, we have to conclude that the divergent development of the early *Papilioni-Nymphalidae* began with a modification of the regular belt of bristles into an irregular transverse ventral series, the appearance of setiferous punctures, and with a basad restriction of the sense-hairs on the distal joints.

Now, where have the *Hesperiidae* to come in? Did they branch off **before** or **after** the divarication of the Butterflies into a Papilioni-Nymphalid and a Lycaeno-Erycino-Pierid phylum took place? If the *Hesperiidae* are a development **posterior** to the divarication of the two phylums, they must belong to the Lycaeno-Erycino-Pierid phylum; for the Hesperids have not one of the specialisations by which the *Papilioni-Nymphalidae* are characterised, and cannot, therefore, have departed **with** them from the ancestral stock. Hence it remains only to consider from which point of the second phylum the Hesperids shot off. The antennae of *Hesperiidae* have most characters of an ancestral type, and hence resemble the antennae of Lycaenids which are also ancestral: this resemblance finds an explanation in both families being derived from the common ancestor of all Butterflies. The specialisations are such as occur in all or nearly all other families, or are peculiar to the skippers (for instance, the possession of three bristles in certain Hesperids, f. 4), and hence are indifferent in respect to the present question: only the apical position of the ventral belt of bristles points to a connection with *Lycaenidae*, but not conclusively, as we have seen. The large extent of ventral and dorsal scaling, and the specialisations in the bristles, are equally well explained, if we assume the *Hesperiidae* to be derived from the Lycaeno-Erycino-Pierid phylum before the odd-grooved *Erycino-Pieridae*

* As this result is in the main point entirely at variance with the current views of entomologists as to the classification of the Butterflies, I expect to be criticised, and give expression to the hope that the criticisms will be intrinsic. But I must state here, that I shall not answer arguments from other organs than antennae, as the other organs will be treated upon in subsequent instalments of these contributions.

branched off, or after the separation of this branch; the Hesperids may be a very old branch of the phylum, or they may be a relatively young one, that stands in a somewhat similar relation to the *Lycaenidae* as the *Dismorphiinae* do to the other *Pieridae*: the antennae do not tell us which assumption is correct.

However, it is not necessary to assume that the *Hesperiidae* branched off **after** the Butterflies had developed into two phylums; it is quite intelligible that they separated from the ancestral stock **before** a separation into the two main phylums had taken place. The presence of scaling on the dorsal side of all the joints in all the species—a character which is equally constant only in families of Moths; the very constantly great development of ventral scaling; the long tapering club of most species—a specialisation which is peculiar to the *Hesperiidae* among Butterflies, but is found also in some Moths, *Cocytia* for instance; and especially the absence of all those specialisations by which the *Lycaeno-Erycino-Pieridae* are distinguished from the *Papilioni-Nymphalidae*, **suggest** that the *Hesperiidae* originated **before** the two main phylums of Butterflies had separated; but the evidence for this third possibility, the separate origin of the skippers, is also entirely inconclusive.

The connection between the various families thus deduced may be illustrated by the following diagram:—

The uncertainty as to the position of the *Hesperiidae* is very suggestive, if we remember that the Hesperids and Lycaenids are so often very similar to each other in their antennae. This similarity consists in both families possessing **ancestral** characters, which, as said before, find their explanation in the origin of the two families from the same ancestral stock, and do not imply that the *Hesperiidae* and *Lycaenidae* separated relatively lately. As we have seen that, notwithstanding the agreement of the two families in several generalised characters, the *Hesperiidae* can very well have branched off before the *Papilioni-Nymphalidae* parted from the rest of the Butterflies, we have here an instructive illustration of the fact—so very often entirely disregarded in classificatory work—that the presence of the same character in two different families (or higher or lower categories, down to individuals), though demonstrating origin of both from a common ancestral form, can be, or is, evidence of **closer** relationship only, if the character is a specialisation and not of the ancestral type.

EXPLANATION OF PLATES XIV. AND XV.

If not otherwise specified, the figure represents the antennal joints in a ventral view.

Hesperiidae.

Fig. 1. *Ismene iphis* (1773), Drury, *Illustr. Ex. Ent.* II. t. 15. f. 3. 4.
„ 2. *Heteropterus palaemon* (1771), Pallas, *Reise* I. p. 471.
„ 3. *Achlyodes pallida* (1869), Felder, *Verh. z. b. Ges. Wien.* p. 478. n. 38.
„ 4. *Entheus gentius* (1779), Cram., *Pap. Ex.* II. t. 179. f. c.
„ 5. *Kerana* spec. from Formosa.

Lycaenidae.

„ 6. *Lucia aurifera* (1853), Blanch., *Voy. au Pôle Sud.* t. 3. f. 13. 14.
„ 7. *Liptena* spec.
„ 8. *Lycaena iolas* (1816), Ochs., *Schmett. Eur.* IV. p. 144.
„ 9. *Theela cyllarus* ♀ (1775), Cram., *Pap. Ex.* I. t. 25. f. c. d : lateral view.

Erycinidae.

„ 10. *Necyria saundersi* (1854), Hew., *Tr. Ent. Soc. Lond.* (2). II. p. 245. t. 22. f. 1.
„ 11. *Nemeobius lucina* (1758), Linn., *Syst. Nat.* ed. X. p. 480. n. 135.
„ 12. *Helicopis endymion* (1782), Cram., *Pap. Ex.* III. t. 244. f. c. d.
„ 13. *Ancyluris meliboeus* (1777), Fabr., *Gen. Ins.* p. 271.
„ 14. *Nymphidium arche* (1865), Hew., *Ex. Butt.* III. *Nymph.* t. 2. f. 10.

Pieridae.

„ 15. *Colias croceus* (1785), Fourcr., *Ent. Paris.* II. p. 250.
„ 16. „ „
„ 17. *Gonepteryx rhamni* (1758), Linn., *Syst. Nat.* ed. X. p. 470. n. 73.
„ 18. *Stalachtis phlegia* (1782), Cram., *Pap. Ex.* III. t. 197. f. f.
„ 19. *Nychitona alcesta* (1782), Cram., *l.c.* IV. t. 379. f. a.
„ 20. *Nathalis iole* (1836), Boisd., *Spec. Gén.* I. p. 589 ; club.
„ 21. *Mesapia peloria* (1853), Hew., *Ex. Butt.* I. *Pier.* t. 2. f. 15 : dorsal view.
„ 22. „ „
„ 23. *Hebomoia glaucippe* (1758), Linn., *Syst. Nat.* ed. X. p. 469. n. 65.
„ 24. *Pieris brassicae* (1768), Linn., *l.c.* p. 467. n. 58.
„ 25. *Eurema albula* (1775), Cram., *Pap. Ex.* I. t. 25. f. e.
„ 26. „ *bogotana* (1861), Feld., *Wien. Ent. Zeit.* V. p. 84. n. 41.
„ 27. „ *hecabe* (1758), Linn., *l.c.* p. 470. n. 74.
„ 28. *Pseudopontia paradoxa* (1869), Feld., *Pet. Nouv. Ent.* no. 8.
„ 29. *Leucophasia sinapis* (1758), Linn., *l.c.* p. 468. n. 61.
„ 30. *Dismorphia thermesia* (1819), Godart, *Enc. Méth.* IX. p. 164. n. 154.
„ 31. „ *eumelia* (1782), Cram., *Pap. Ex.* III. t. 280. f. d.

Papilionidae.

„ 32. *Parnassius apollo* (1758), Linn., *l.c.* p. 465. n. 41 : club.
„ 33. „ „ stalk.
„ 34. „ *stubbendorfi* (1848), Ménétr., *Ins. Lehm.* p. 57. n. 711. t. 6. f. 2.
„ 35. „ *apollo*, Linn., *l.c.* : stalk, dorsal view.

Fig. 36. *Papilio agamemnon* ♀ (1758), Linn., *Syst. Nat.* ed. X. p. 462. n. 21.
„ 37. „ „ „ lateral view.
„ 38. *Leptocircus curius* (1787), Fabr., *Mant. Ins.* II. p. 9. n. 71.
„ 39. „ „ lateral view of joints of club.
„ 40. *Papilio philoxenus* (1831), Gray, *Zool. Misc.* p. 32.
„ 41. „ *ambrax* ♀ (1832), Boisd., *Voy. Astrolabe, Ent.* p. 40. n. 5.
„ 42. „ „ ♂.
„ 43. *Armandia lidderdali* (1873), Atk., *P.Z.S.* p. 571. t. 50; lateral view.
„ 44. *Sericinus telamon* (1798), Don., *Ins. China.* t. 27. f. 1.; „ „
„ 45. *Luehdorfia japonica* (1889), Leech, *Entom.* XXII. p. 25. t. 1. f. 1.
„ 46. „ „ dorsal view.

NYMPHALIDAE.

„ 47. *Callinaga buddha* (1857), Moore, *Cat. Lep. Mus. E. I. C.* I. p. 163. n. 336. t. 3a. f. 5.
„ 48. *Pseudergolis avesta* (1867), Feld., *Reise Novara, Lep.* p. 404. n. 604.
„ 49. *Libythea celtis* (1782), Fuessly, *Arch. Ins.* t. 8. f. 1—3; lateral view.
„ 50. „ *antipoda* (1859), Boisd., *Bull. Soc. Ent. Fr.* p. 157. n. 9; lateral view.
„ 51. „ *antipoda*; stalk, ventral view.
„ 52. „ *moluccana* (1860), Feld., *Sitzb. Akad. Wiss. Wien., Math. Nat. Cl.* XL. p. 449. n. 4.
„ 53. *Heliconius thelxiope* (1806—1816), Hübn., *Samml. Ex. Schm.*
„ 54. „ „ club, dorsal view.
„ 55. *Epinephele janira* (1758), Linn., *l.c.* p. 475. n. 106.
„ 56. *Satyrus dejanira* (1764), Linn., *Mus. Lud. Ulr.* p. 282. n. 100.
„ 57. *Sinchula maitrya* (1880), Nicév., *Journ. As. Soc. Beng.* p. 245.
„ 58. *Ipthima asterope* (1832), Klug, *Symb. Phys.* t. 29. f. 11—14.
„ 59. *Triphysa dohrni* (1850), Zeller, *Stett. Ent. Zeit.* p. 308.
„ 60. *Taygetis erubescens* (1868), Butl., *Cat. Sat. B. M.* p. 10. t. 1. f. 2; dorsal view.
„ 61. *Brassolis astyra* (1819), Godart, *Enc. Méth.* IX. p. 457. n. 2.
„ 62. *Calligo ilionaeus* (1779), Cram., *Pap. Ex.* I. t. 52. f. A.
„ 63. *Tenaris bioculatus* (1829), Guér., *Voy. Coquille.* t. 17. f. 1.
„ 64. *Discophora cheops* (1867), Feld., *Reise Novara, Lep.* p. 463. n. 783.
„ 65. *Araschnia levana* (1758), Linn., *l.c.* p. 480. n. 133.
„ 66. *Parthenos gambrisius* (1787), Fabr., *Mant. Ins.* II. p. 12. n. 113.
„ 67. *Vanessa antiopa* (1758), Linn., *l.c.* p. 476. n. 112.
„ 68. *Thyridia psidii* (1758), Linn., *l.c.* p. 466. n. 51; stalk.
„ 69. „ „ club.
„ 70. „ „ club, dorsal view.
„ 71. *Danaus plexippus* (1758), Linn.; Cram., *Pap. Ex.* III. t. 206. f. E.
„ 72. „ *croceus* (1866), Butl., *P.Z.S.* p. 57. n. 53. t. 4. f. 5.
„ 73. „ „ club, dorsal view.


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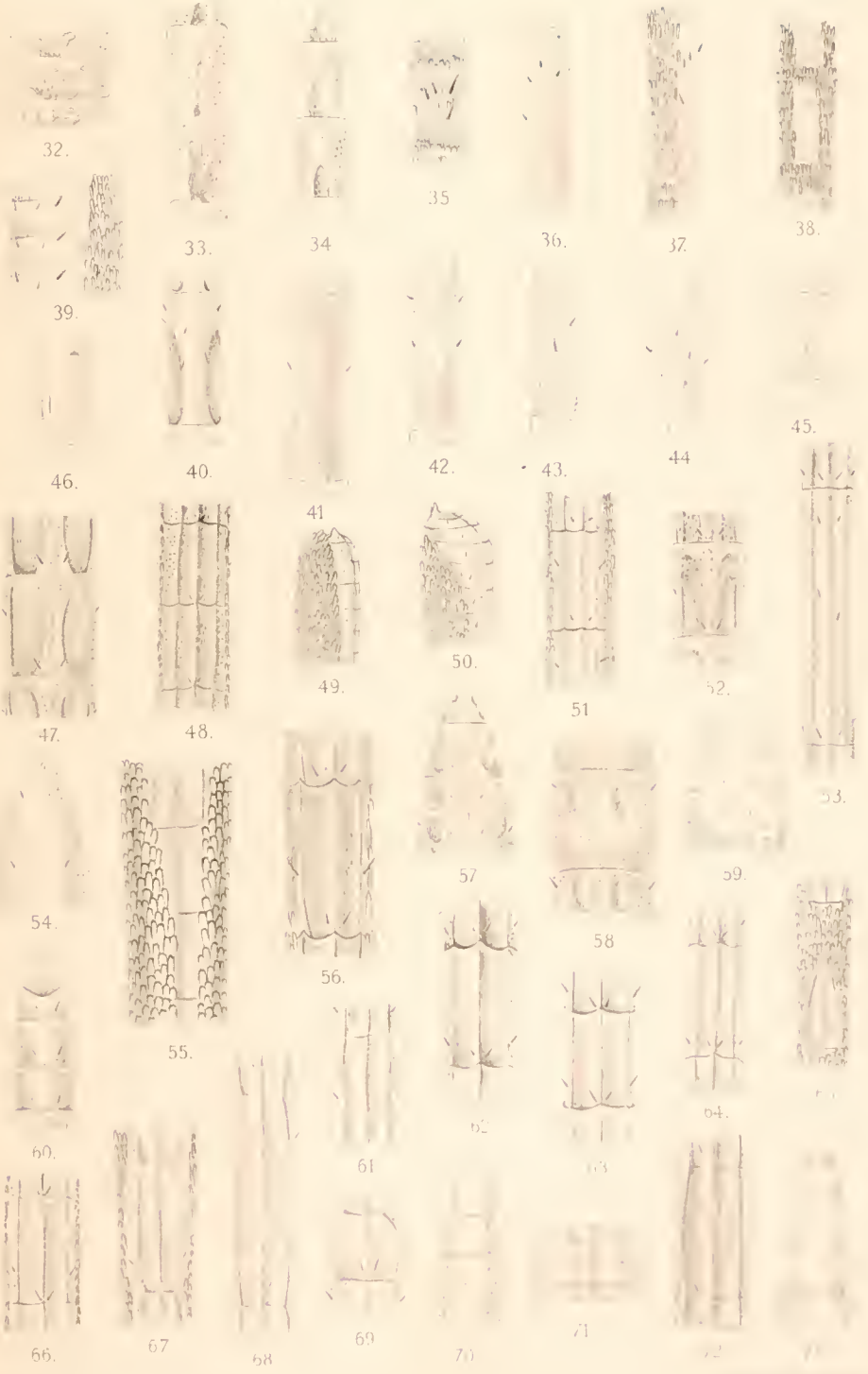
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